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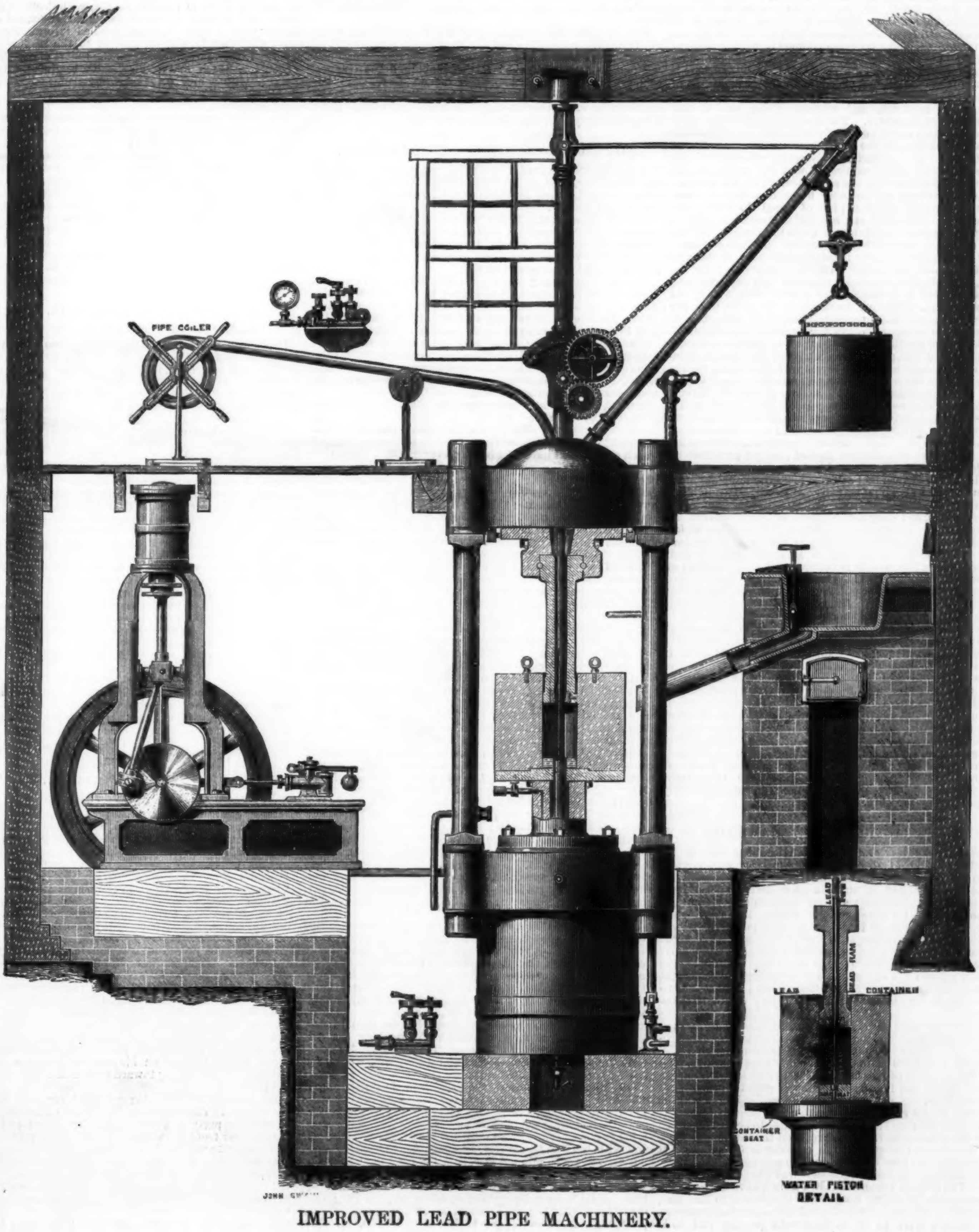
LEAD PIPE MAKING MACHINERY.

ALTHOUGH the use of lead pipes is universal, it does not follow that every one knows how they are made. Formerly they were all produced by drawing through dies, and this system is still followed. The method of "squirting," however, gives better results. It was first designed, we believe, for the production of rods of compressed lead in the manufacture of bullets. Messrs. Weems, of Johnstone, N. B., have, however, brought machinery of this kind to perfection, which we here illustrate. We are indebted to the *Engineer* for our engraving and these particulars. The special machinery for the lead trade made by this firm includes patent hydraulic machinery for the manufacture of solid block tin and block tin composition tubes, patent solid block tin-lined lead pipe, lead composition and tinned composition pipes, lead rods for bullets, window leads for glass, etc., all in long lengths.

This patent hydraulic machinery consists of strong copper-lined hydraulic cylinder, ram, and crosshead, having a central opening, and supported by four wrought iron columns, bound to the hydraulic cylinder. The ram is fitted with a portable lead container, supported thereon, and to the crosshead is fixed a ram or plunger, within which is fitted a die for forming the outside of the pipe; the core for forming the inside of the pipe is fixed in the center of the lead container. The molten lead is conveyed from the



IMPROVED LEAD PIPE MACHINERY.

melting pot by a portable conductor to the container, and after being filled and allowed to set or solidify at a temperature of about 400 deg. Fah., the water ram being then forced up by the hydraulic pumps at a pressure of from 25 cwt. to 30 cwt. per square inch, raises the container, and presses the surface of the metal against the face of the lead ram and die, and the metal, having no other means of escape, passes out through the aperture between the core and the die, resulting in the continuous formation of a solid pipe, until the metal in the container is exhausted, when the hydraulic return motion in connection with the pumps is put into operation, and the lead container returns to its original position, and is then refilled.

In the interior of the water ram is fitted a small intermediate ram, for the purpose of rapidly changing the cores without removing the containers, as was usually done on the old principle for making the different sizes of pipes; and by connecting hydraulic pipes from the pumps, the same is put into operation when desired. The machine is provided with a safety self-acting stop motion, whereby the container, when it has traveled the desired distance, opens the bottom valve, allowing the water to escape to the cistern.

For making lead rods for bullets, lead wire, etc., the core for forming the inside of the pipe is dispensed with, and a die fitted into the lead ram of the diameter of the lead rod or wire desired. The hydraulic pumps may either be driven direct by a vertical or horizontal steam engine, water power, or from gearing, the driving pulley being provided with a clutch. These machines are in operation in the principal lead works of Great Britain, Russia, America, Spain, Mexico, Portugal, Peru, Brazil, etc., and for the production of lead rods for rifle bullets in the Woolwich Arsenal, as well as in the arsenals of foreign Governments and in various ammunition factories. The advantage claimed is that the core for forming the inside of the pipe, being fixed in the container and surrounded by the metal, travels with it, so that there is no actual frictional contact except at the point of escape of the exuding metal, and the pipe is produced while the body of the metal is at rest, and without giving rise to any frictional effect elsewhere. The lead container being open at the top affords every facility for removing the impurities of metal which float on the surface and are skimmed off, and the lubrication of the lead ram is easily effected at each change. No fire being required round the container, the expansion and contraction are equalized. The die requires no adjusting screws, as the core has a tendency to come true to the center to make a pipe of equal thickness, and the metal being pressed at a reduced temperature gives a solidity and superior brilliancy of finish to the pipe. Owing to the reduction of the frictional contact the lead container can be made larger, thereby increasing the size of the pipe and the quantity produced. The lead containers for the large and small pipes are easily removed and replaced, and the machine can be worked at the rate of from five to six charges per day, producing from about 25 to 30 tons per week. The latest improvements effected in this class of machinery are in the appliances for the production of tinned-lined lead pipe produced at one operation under hydraulic pressure of 200 tons per square inch, such as moulds, mandrels, etc., thereby producing an improved medium for the supply of pure water to dwellings, preventing lead poisoning of water and other liquids. Messrs. J. and W. Weems have long endeavored to produce machinery which would turn out a pipe for domestic purposes entirely free from contamination with lead, and in this way they have produced the lined lead pipe. This pipe may be termed a combination pipe. It consists of a distinct pipe of pure tin protected by an outside covering of lead, and the two pipes are so united at their surfaces of contact as to be inseparable by any contortion to which the pipe may be subjected. In pliability it does not differ in any perceptible extent from lead pipe, as it is easily bent to any desired form or angle without in the slightest degree affecting the interior of the pipe, which comports itself physically as a part of the body of the lead pipe. It is stated that this pipe is so much stronger than lead pipe that a less weight is needed, and thus the cost of the two is the same. The Government of Brazil have recognized its value by stipulating for the use of this piping only for the entire service of the city of Rio de Janeiro, and on the Continent several municipalities are using it solely.

Messrs. Weems had a curious experience in the attempt to produce brass tubing by hydraulic pressure. For this purpose they constructed a water press with a 33 in. ram. It was found that when the brass block out of which the pipe was to be formed came to be subjected to a pressure of 4,000 tons, the zinc left the copper, thereby producing a zinc pipe and leaving the copper behind. This result, which was surprising and unexpected, formed really a contribution to science, by proving that the atoms of the brass composition united together by fusion were only mechanically arranged, and not chemically combined, and practically demonstrating the truth of the atomic theory of Professor Tyndall, that in compound substances the component materials were held together by pressure, and could thereby be separated by pressure.

ARTILLERY PRACTICE AT FORT HAMILTON, N. Y.

The heavy artillery practice at Fort Hamilton, Oct. 15, included the firing of the 20-inch Rodman smooth-bore, of which only one is mounted in the U. S. It is at present the largest gun mounted in our sea-coast defenses; has been fired but a very few times, and but little data pertaining to it is available. Its carriage was broken last year, when firing with a charge of 200 lb. hexagonal powder. It was repaired, and it was thought that even a larger charge might be safely fired. Again a charge 200 lb. hexagonal powder and solid shot of 1080 lbs. were tried, and again was the carriage injured. This time injury was comparatively slight and was readily repaired. Had there been a few more gallons of oil in the buffer cylinder, no injury would have occurred.

The powder used was of more recent manufacture than that used last year, and a greater pressure was probably produced, for while at the previous firing the range with 9 deg. elevation was 3,100 yards, 3,114 yards were obtained with only 6 deg. It is proposed in future firings to use a charge of only 150 lb. and increase the charge gradually, while, at the same time, the contents of the hydraulic buffer will be increased with a view of obtaining such relation between the charge and the recoil as to cause the latter to be just absorbed when the gun and carriage have reached the loading position. The maximum contents of the cylinder is 56 gallons. It contained at the time of firing only 40 gallons.

The direction of the 20-inch shot was almost perfect as to line. The 15-inch Rodman smooth bore was then fired, and as soon as the resulting range was telephoned to the gun, four guns of this caliber were loaded and sighted at the target. The charges were of 80 lb. mammoth powder and solid shot of about 450 lb. Fired simultaneously by electricity, the four projectiles were seen to move nearly abreast, and it seemed as if they would collide ere the target was reached. Finally a great column of water appeared to drown the target, while another column appeared somewhat later and somewhat to the left. The floating target, nine feet square, was struck by one of the shot, three having struck within a space which would have been covered by the deck of a 20-ton schooner. This round closed the day's firing. During the firing the wind blew freshly, from 18 to 24 miles per hour, fishtailing in directions from V to VII o'clock. Notwithstanding this, and the fact that the guns fired were smooth-bores, the deviations were comparatively slight. November 1st, the 20-inch gun was fired with a charge of 150 lb., the hydraulic buffer containing 45 gallons of neutral oil. The elevation was 14 deg., and the gun recoiled so that the carriage struck the rear rubber buffers and recoiled from these two inches, no injury having resulted. The target was at a distance of about 3,007 yards and the shot was nearly perfect as to line, but 90 yards short. The wind was variable from 14 to 30 miles per hour, and the first allowance made amounted to 58 yards. Before firing, the wind was found to have decreased and the defective allowance was reduced by 25 yards, leaving the gun still pointing to the right of the target 32 yards.

Eight rounds were fired with the 15 in. with good results as to line, but a relatively wide dispersion as to range. Four rounds were fired in volley; the target remained intact. The range of more than two miles appears to be too great for this gun with the charge used, and it can only be used successfully for long ranges in volley firing of larger number of guns.

Nov. 6.—The firing was with the 4½ in. siege guns, using old Hotchkiss projectiles and 3¼ lb. mortar powder. The practice was excellent as to direction, but the ranges obtained were not as uniform. The target was anchored at a distance of 2,555 yards. One shot pierced the bull's-eye, the other striking closely both short and over. The firing will be continued as long as the weather will permit out of door work advantageously.—*Army and Navy Journal.*

NOTABLE LOCOMOTIVE PERFORMANCES.

A recent number of *The Engineer* contains diagrams of the Gladstone, one of Mr. Stroudley's locomotives, running on the London, Brighton & S. C. Railway. We give some of the results:

Cut-off, 75 per cent.; boiler pressure, 110 lb.; steam chest pressure, 110 lb.; speed, 9 miles per hour = 39 revolutions per minute; gradient, 1 in 313 up; number of carriages, 13; approximate weight of train and passengers, 118 tons 18 cwt.; total indicated horse power=238·4.

Cut-off, 58 per cent.; boiler pressure, 125 lb.; steam chest pressure, 100 lb.; speed, 56 miles per hour = 242·66 revolutions per minute; gradient, 1 in 660 down; number of carriages, 18; approximate weight of train and passengers, 178 tons 12 cwt.; total indicated horse power = 1040·88.

Cut-off, 50 per cent.; boiler pressure, 110 lb.; steam chest pressure, 110 lb; speed, 65 miles per hour = 281¼ revolutions per minute; gradient, 1 in 660 down; number of carriages, 16; approximate weight of train and passengers, 143 tons 3 cwt.; total indicated horse power = 738·94.

Cut-off, 50 per cent.; boiler pressure, 125 lb.; steam chest pressure, 125 lb.; speed, 65 miles per hour = 281¼ revolutions per minute; gradient, 1 in 264 down; number of carriages, 16; approximate weight of train and passengers, 143 tons 3 cwt.; total indicated horse power = 906.

Cut-off, 75 to 33 per cent.; boiler pressure, 115 lb.; steam chest pressure, 105 lb.; speed from 0 to 30 miles per hour; gradient 1 in 313 down; number of carriages, 8; approximate weight of train and passengers, 64 tons 8 cwt.

Cut-off, 17 to 50 per cent.; boiler pressure, 135 lb.; steam chest pressure, 130 to 110 lb.; speed, 50 to 51 miles per hour; gradient, 1 in 264 up; number of carriages, 10; approximate weight of train and passengers, 91 tons 6 cwt.

Cut-off, 62 per cent.; boiler pressure, 130 lb.; steam chest pressure, 100 lb.; speed, 53 miles per hour = 229·6 revolutions per minute; gradient, 1 in 264 down; number of carriages, 16; approximate weight of train and passengers, 146 tons 6 cwt.; total indicated horse power = 933·6.

Cut off, 62 per cent.; boiler pressure, 115 lb.; steam chest pressure, 100 lb.; speed, 60 miles per hour = 260 revolutions per minute; gradient, 1 in 264 down; number of carriages, 25; approximate weight of train and passengers, 305 tons 11 cwt.; total indicated horse power, 951·6

Cut-off, 50 per cent.; boiler pressure, 125 lb.; steam chest pressure, 120 lb.; speed, 65 miles per hour = 281¼ revolutions per minute; gradient, 1 in 264 down; number of carriages, 16; approximate weight of train and passengers, 145 tons 5 cwt.; total indicated horse power = 787·2.

Cut-off, 33 per cent.; boiler pressure, 110 lb.; steam chest pressure, 105 lb.; speed, 67 miles per hour = 290·3 revolutions per minute; gradient, 1 in 264 down; number of carriages, 25; approximate weight of train and passengers, 305 tons 11 cwt.; total indicated horse power=512·4

Cut-off, 73 to 17 per cent.; boiler pressure, 140 lb.; steam chest pressure, 90 to 120 lb.; speed, 15 to 20 miles per hour; gradient, 1 in 264 up; number of carriages, 13; approximate weight of train and passengers, 112 tons 10 cwt.

Cut-off, 66 per cent.; boiler pressure, 135 lb.; steam chest pressure, 120 lb.; speed, 58 miles per hour = 251·3 revolutions per minute; gradient, 1 in 1,328 down; number of carriages, 16; approximate weight of train and passengers, 170 tons; total indicated horse power = 1,089·0.

It will be seen that there is a certain speed at which the power exerted, 1,080 horses, is greatest. The back pressure is in nearly all cases very small for a locomotive, and it may be mentioned here that the engines on the London & Brighton Railway do not throw sparks, and the smoke box temperature is so low that a piece of waste tied to the exhaust pipe by one end will remain unconsumed for a considerable period. This experiment has actually been tried. The result is due, no doubt, to the large calorimeter of the tubes, and to the peculiar method adopted for working the fire, which is really more a gas furnace than anything else.

As to the consumption of fuel and water, we give the following particulars:

On Monday, October 8, the Gladstone left Brighton at 8·45 A.M., with twenty-five coaches; distance run 50 miles 49 chains; time, one hour and nine minutes; gross weight of train, including engine and tender, 350 tons; water used, 1,400 gallons. The engine returned to Brighton on the same day with the 5 P.M. express, 14 coaches. Started to time, but arrived seven minutes late, being stopped ten minutes by signal; running time, one hour and seven minutes; gross weight of train, 225 tons; water used, 1,250 gallons. Average load for day's work, 19·5 vehicles; miles run, 101 18c.; vehicle miles, 1,973 71c.; coal consumed, 28 cwt.; consumption per train mile, 30·98 lb.; per vehicle mile, 1·58 lb. If 10 lb. per train mile be allowed for engine, the consumption per vehicle mile would be 1·08 lb. Water used, 2,650 gallons; pounds of water to pounds of coal, 8·45; average temperature of feed water, 152·5; average boiler pressure, 132·5 lb.; weather fine. No allowance is made here for coal consumed while standing under steam and shunting. In considering the evaporation, allowance must be made for the water returned to the tender in the shape of steam. If the performance of this engine be compared with that of the compound locomotive of Mr. Webb, it will be found that the advantage claimed for the latter does not come out very prominently.

Want of space has prevented us from referring particularly to many things connected with Mr. Stroudley's practice as embodied in the Gladstone, which are well worth notice. What we have written, however, and our illustrations, will suffice to give our readers an excellent idea of the peculiarities of the engine, and they will suffice to prove that Mr. Stroudley has succeeded in designing and building an engine of sufficient merit to place him in the first rank as a locomotive engineer.

WRECK OF A BRIDGE BY WIND.

Cleveland, Columbus, Cincinnati, and Indianapolis, and Indianapolis and St. Louis Railway Companies.

Cleveland, O., June 6, 1883.

To the Editor of the Railroad Gazette:

The destruction on May 18 of our Hillsboro' bridge and consequent wreck of passenger train, with death of both engineer and fireman, occurred under such unusual circumstances that I have thought detailed information of the cause might not be without interest to the readers of your paper. I, therefore, inclose you the report of our Chief Engineer, Mr. Beach, and of his Bridge Engineer, Mr. Irwin, together with a blue print showing plan and strain-sheet of bridge as erected and also its condition after cyclone had destroyed it.

This storm seems to have developed a new danger in railroad operations, and one against which as yet neither science nor experience seems to offer any safeguard.

Only some four or five minutes' time elapsed between passage of storm which destroyed bridge and the arrival of train. Had the latter been on the bridge a few minutes sooner, it would seem that the entire destruction of the train, as well as of the bridge, must have occurred, the results of which it would be impossible to estimate.

I give you the facts, and you can put them in such shape, if you desire, as will prove of interest to your readers, and possibly throw some light upon similar occurrences of this nature.

E. B. Thomas,
General Manager.

Cleveland, O., June 6, 1883.

E. B. Thomas, *General Manager:*

Dear Sir: Herewith is submitted to you a report of the disaster at Hillsboro' on the night of May 18, and, owing to its being so unusual and violent, a great deal of care has been taken to get together a detail of the facts connected therewith, and for this purpose Messrs. Irwin and Reuschel were requested to make measurements, and give the position of the structure, track, and surroundings, both before and after the occurrence, and all other details needed for a full and concise report and record, which has been done, and is now handed to you.

It was found that the whirling or rotating motion was the reverse of the movements of the hands of a watch laid face upward, or from right to left with the line of passage, and with sufficient force to raise the bridge and track vertically and carry it in the line of progress an average distance of 23 ft., and to the left of the line of progress 16 ft.

Wm. C. Redfield, in numerous papers upon the phenomena of storms, published in 1831, and continuing over a period of twenty-five years in the *American Journal of Science*, estimated that near the axis of the spiral whirls a wind velocity of 300 miles an hour has been obtained, and that the progress of hurricanes was at a variable rate of from four to 44 miles per hour, usually about 30 miles.

Elias Loomis in his treatise on meteorology recites that a very destructive tornado occurred in Northern Ohio, Feb. 4, 1842, line of progress N. 33° E., with a velocity of 34 miles per hour.

The velocity in the line of progress it would seem was very great to carry such a weight the distance given, and possibly much greater than that given by Redfield and Loomis, the general course being northeasterly. Very respectfully,

G. M. Beach,
General Road-Master.

Cleveland, O., June 4, 1883.

G. M. Beach, *G. R. M.:*

Dear Sir: On Friday, May 18, 1883, at 10 p. m., the iron bridge over Shoal Creek at Hillsboro' Station was blown over, and passenger train No. 12, from St. Louis to Cleveland, ran into the creek, killing engineer and injuring fireman, who subsequently died, they being the only persons hurt.

Pursuant to instructions, in company with Wm. Reuchel, of the engineer's department, and Mr. Maxwell, Superintendent of Bridges, I made an examination of this accident, and, in connection with companying drawing, would submit following report:

The evening preceding was not marked by any unusual disturbances, light showers of rain with thunder and lightning, when suddenly, at 9:55 p. m., Mr. A. H. Brown, who was attending depot, heard a loud rumbling sound similar to an approaching freight train, then a rattling on the windows like shot striking them, followed by door of depot blowing violently open. This lasted for only a moment, seemingly, when, stepping out on the platform, he heard No. 12 whistle for station. He went back into office to get letters for train, and on his way out heard engine whistle for brakes. Hastening toward bridge he found it gone and train in creek.

By referring to drawing you will see that bridge lies nearly upside down on northerly side of abutments, with locomotive party underneath, tender turned end for end, baggage car front end near middle of creek, other end up on bank opposite west bridge seat, smoking car in rear of baggage car, ladies' car back of that, and sleeper on track.

The bridge was a through whipple truss, single intersection, 102 ft. 7 in. long center to center of end pins, weighing 57½ tons unloaded, ties spaced 4 in. apart, oak guard-rail 6 × 8 notched on ties and bolted to every fourth one. Track was steel rail 60 lb. per yard, fastened with angle bars, thus

forming a strong anchorage. Was built and erected by Cleveland Bridge and Car Works, January, 1882, fully up to bridge specifications of Indianapolis & St. Louis Railway, which are very exacting in their requirements, calculated to carry two consolidation engines shackled together, aggregating in weight 80 tons each (engine and tender); also a wind strain of 550 lb. per running foot, 350 lb. of which to be considered as a moving load, a strength sufficient to resist a wind blowing 75 miles per hour. With this arrangement, the iron in main members would not be strained over 10,000 lb. per square inch and laterals 15,000 lb. After erection bridge was tested and found perfectly satisfactory.

Owing to original stone abutments proving defective, the bridge was supported on pile bents until masonry should be rebuilt, which it was the intention to do this year. The pile bents forming bridge-seat were amply strong enough to carry any possible load that could be brought upon them, each pile being capable of supporting 20 tons, and they were capped by heavy timbers, mortised, tenoned, and drift-bolted together in a workmanlike and strong manner.

On examination we find northerly side of bridge buried in creek, also one top chord and top laterals, floor beams standing at an angle of 45°, easterly end of bridge 15 ft. northerly of center of track, westerly end 31 ft.; also find bridge thrown westerly about 16 ft., floor system firmly wedged against top laterals and top chord.

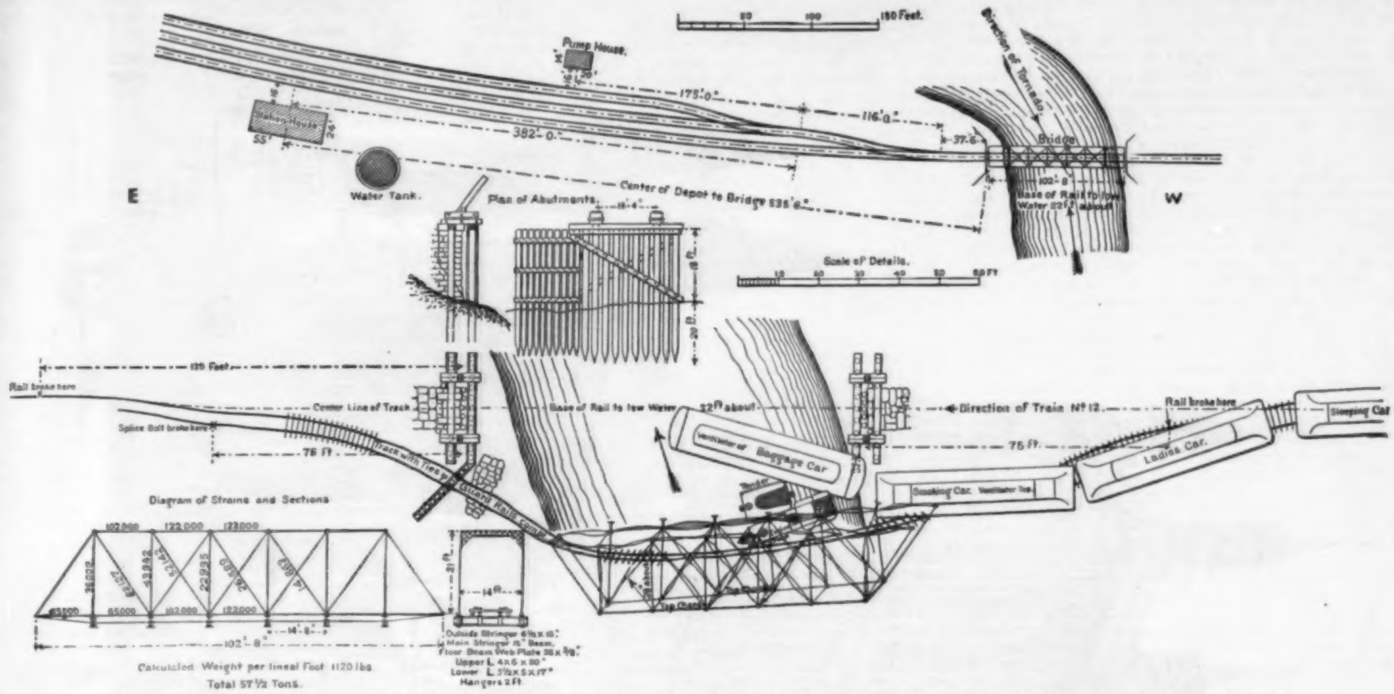
The cyclone, although some 1,000 ft. in width, seemingly concentrated its power underneath bridge, which is 22 ft. above bottom of creek, with embankments extending east and west from 14 ft. in height at bridge to nothing, at distances respectively 500 and 1,800 ft. across valley, striking floor system, breaking loose the joint fastenings of track rail on northerly side and east end of bridge 70 ft. distant, on southerly rail 120 ft. distant, shearing ⅝-in. bolts in angle bars, drawing rails through the spikes some 60 ft. on westerly end, breaking south rail square off 2 ft. from joint at a point 76 ft. from bridge, slewing north rail out as bridge pulled it, taking ties along, then carrying floor system up against top laterals, lifting southerly side of bride off bridge-seat, tearing loose the bridge-seat on northerly side, and finally throwing entire structure over into creek, a mass of ruins, as shown in drawing.

Statistics on the relation between velocity of wind and its pressure against an obstacle are very meager, and seem not well determined. Smeaton's rule for such cases (which is adopted by United States Signal Service), where pressure is at right angles, is the pressure in pounds per square foot, is equal to square of velocity in miles per hour divided by 200. Observations taken in Liverpool in 1860 would give a pressure per square foot almost double preceding rule. The highest recorded velocity of wind per hour on Mt. Washington, N. H., was 180 miles.

Now, in this case, we have weight of bridge 57½ tons, double shearing of four ⅝-in. bolts, representing a resistance of 71 tons, and the transverse breaking of a 60-lb. per yard steel rail, which with resistance of pulling other rails through spike some 60 ft. would represent 72 tons more, making a total resistance of 200 tons to be overcome before bridge could be overthrown. At a fair estimate only 1,200 square feet of surface will be found in bridge for cyclone to operate against, which would require a pressure of not less than 333 lb. per square foot. Assuming this to be at right angles would, according to Smeaton, represent a velocity of wind equal to 257 miles per hour.

Although this velocity of wind is greater than any record we have been able to find, still the fact exists that we have this weight and resistance of 200 tons which was overcome by power of the wind, and the conclusion is inevitable.

This cyclone extended over a number of miles south and



WRECK OF BRIDGE AND TRAIN BY WIND ON THE INDIANAPOLIS AND ST. LOUIS ROAD NEAR HILLSBORO, ILL.

WRECK OF BRIDGE AND TRAIN BY WIND ON THE INDIANAPOLIS AND ST. LOUIS ROAD.

GLOUCESTER CATHEDRAL. (DRAWN BY THE LATE S. READ.)

north of bridge, destroying both lives and property. A sulphurous smell was plainly discernible in the atmosphere after the storm, which, taken in connection with numerous balls of fire seen rising upward and exploding in the clouds, the singed and burnt leaves, the withered and cooked appearance of the trees, unmistakably shows the existence of large quantities of electricity, well giving it the name of an electric cyclone.

In conclusion we would say that this bridge in strength and manner of construction was of the most approved form, and everything had been done to render it safe that human ingenuity could devise, and this accident again forcibly illustrates how puny are the works of man when coming in contact with the actions of the Almighty.

All of which is respectfully submitted.

W. C. IRWIN, *Engineer of Bridges.*

GLOUCESTER CATHEDRAL.

THIS fine ecclesiastical edifice was, until 1539, the period of the dissolution of the monasteries, the church of a wealthy Benedictine abbey, founded in 1022 by Canute, the site having, in early Saxon times, been occupied by a nunnery, which was dispersed in 767. The Norman abbey church having been partly destroyed by fire, though the original Norman piers of the nave still remain, it was rebuilt at various periods, in the Gothic styles of the thirteenth, fourteenth, and fifteenth centuries, while much of the older internal masonry was recased perpendicular Gothic, of which this cathedral affords one of the earliest English examples, more especially in the transepts and choir, executed from 1329 to 1377. The cloisters, the great tower, and the Lady Chapel are of later date, the last belonging to the reign of Henry VII.

No more beautiful specimen can be found of richly-groined vaulting, of the fan-like pattern which is peculiar to English perpendicular in its latest stage, than the roof of the cloisters, the south walk being remarkable also for twenty elegant arched recesses, called " the carrols," each with a small window, to be used by the monks for retirement in study.

The principal feature of the exterior of this cathedral is the noble central tower, which may compare with that of Canterbury; its parapets are adorned with light open tracery of singular beauty, and the pinnacles are equally graceful. The whole composition of the exterior, viewed from the southeast, with its roof-lines of choir and eastern chapel, choir-aisles, and transepts which are (short) leading up to the tower at the central point of intersection in the ground plan, has a most harmonious architectural effect.

The interior has its own characteristic glories in the lofty Norman piers and side arches of the nave, and the magnificent east window of the choir; which last-mentioned part of the building, constructed by Abbots Staunton and Horton, in the fourteenth century, is nowhere exceeded in beauty of ornamentation.

Among the sepulchral monuments is that of King Edward II., who was murdered in Berkeley Castle in 1327, and this tomb was erected at the cost of his son, Edward III.; it supports a recumbent statue of the ill-advised and unlucky king, the face bearing a strong family likeness to those of Edward the Black Prince at Canterbury, and of King Edward III. in Westminster Abbey. The effigy of Duke Robert, eldest son of William the Conqueror, is also found in this cathedral, that prince having died a prisoner in Cardiff Castle.

The episcopal see of Gloucester, founded in 1541, was held by Bishop Hooper, one of the Protestant Martyrs, and subsequently by many respectable prelates, but few of great renown; Bishop Warburton, appointed in 1760, was the editor of Pope's writings, and an author of some literary importance in his time. The Right Rev. Dr. C. J. Ellicott, who has been about twenty years Bishop of Gloucester, is a learned and judicious Biblical scholar and commentator whose critical labors in revising and annotating the New Testament have been justly esteemed. Mrs. Ellicott is a lady of considerable accomplishments in the knowledge of music.—*Illustrated London News.*

BRICKWALL DISFIGUREMENT.

THE extensive use of red bricks (remarks the *Globe*) which has been made of late years for houses and public buildings has caused a good deal of attention to be directed to a curious disfigurement to which such structures are liable, in the form of a kind of white mould which is apt to creep over their surfaces. The best of buildings are quite as subject to this detraction from their appearance as the worst, the new Technical College at South Kensington, for instance, being just now covered in places with this objectionable kind of eruption, which is not very generally understood, and for which no remedy has yet been found, we believe, except time. An American paper publishes one or two scientific opinions on the matter, one being that of Dr. Leidy, President of the Academy of Natural Sciences. According to this authority, the white efflorescence is simply ordinary Epsom salts, or sulphate of magnesia, and the production of it on brick surfaces must be regarded as evidence of the presence of sulphurous acid in the air, the result of coal-burning. There is magnesia in the mortar with which the walls are built, and there is sulphurous acid in the air, and in the presence of moisture a chemical combination takes place, the result being sulphate of magnesia. This dissolves in the rain and runs down over the bricks, and evaporation leaves the white deposit. Another chemist agrees that this is the way in which the efflorescence is produced, but thinks that it is potash with which the sulphurous acid combines, and that the white is sulphate of potash, while another authority considers it to be sulphate of lime. All agree, however, that it is the sulphurous acid in the air which causes this disfigurement, and this is really the important aspect of the matter. If this is the effect of atmospheric impurity on brick buildings, it seems reasonable to suppose that it must be somewhat serious in its influence on human lungs.—*Building Times.*

REMOVING PAINT FROM OAK CARVINGS.

NOT long ago an attempt was made to remove the accumulated paint from the carved oaken doors of the Berlin Arsenal. Our method of burning off was not suited to such work, nor does it leave the wood in its natural beauty. It was found that a solution of caustic soda (strength not stated) would completely remove five or six coats of paint, and restore the natural color of the wood. It was applied with a brush made of bristles, and after a while rinsed off with water. The operation must be repeated several times according to the thickness of the paint, but some caution is necessary to prevent the wood checking. The surface of the wood is roughened by the lye and rinsing; if this is carefully smoothened off and then covered with wax and varnish, the carving is restored to its original freshness.—*Centralblatt der Bauverwaltung.*

GLOUCESTER CATHEDRAL. (DRAWN BY THE LATE S. READ.)

ALFRED NIAUDET.

DEATH has indeed been busy in the electrical world this year. It is but a few weeks since Cromwell Varley and Richard Werdermann were taken away, and now the melancholy duty devolves upon us of recording the death of Alfred Niaudet. M. Niaudet was a member of the well known firm of Breguet of Paris, and in this capacity made the acquaintance of many of the best known electricians and inventors of the day, both in France and England. His death appears to have been sudden and almost unexpected. He died on the 11th inst., at the age which is usually considered the prime of life, viz., forty-eight.

Evidence of M. Niaudet's activity and capability is to be seen in the fact that in addition to the duties devolving upon him as a member of the firm of Breguet, he found time to discharge those of manager of the Société Générale des Telephones, of the Compagnie Electrique, and of the Societe d'Eclairage Electrique, as well as those of Chairman of the Compagnie Internationale des Telephones. He was a member of various scientific societies, among others the Societe Francaise de Physique. He was also elected a foreign member of our own Society of Telegraph Engineers and of Electricians on May 8, 1872.

He was a frequent contributor to the French scientific press, notably to *La Rèvue Industrielle, L'Electricien,* and *La Nature.* He also contributed some original communications to the *Journal of the Society of Telegraph Engineers.* He was the author of several works, among which were "Applications du diapason, a l'horologerie," published in 1866; "Machines Magneto-Electriques Gramme," published at Paris in 1875, and written in the name of A. Niaudet-Breguet; "Telephones et Phonographes, etude complete de ces inventions," Paris, 1878; "Traite elementaire de la Pile Electrique," Paris, 1878, of which on English translation was made by L. M. Fisbach, and published in New York in 1880; and "Machines Electriques à Courants Continus," of which a second edition was published in 1881. His researches on dynamos and batteries entitle him to a high rank among those who have studied in this direction.

He took an active part in the proceedings incident to the Great Electrical Exhibition at Paris, in 1881, and the congresses which were held at the same time. We find his name among the chancellerie of the International Congress of Electricians, while he was also elected president of one of the sections of the Reunion of Electricians held at the same time as the Congress.

During the Franco-Prussian war of 1870–71, M. Niaudet spared neither money nor labor in his country's cause. In 1870 he was shut up in Metz with the Army of the Rhine, and devoted himself to organizing its telegraph service. While in this city he devised several means of communication with the outside w rld, but with what success we do not know. Finally he escaped from Metz and joined the Army of Defense.

His activity and energy are well known, and his authority on questions of electrical science and practice unquestionable. We may quote here a paragraph from a brief notice of his death that appears in the *Rèvue Industrielle* of Wednesday last. Our contemporary says:

"Inventors always experienced a kindly reception at his hands; workmen consulted him to their benefit, while *savants* themselves appreciated his experience. An inventor of an electric battery, he was one of the first to foresee the part that would be played by machines in the production of electricity; indeed, he had himself designed a small and very ingenious machine for laboratory use."

He was a frequent visitor to this country, and rarely failed to acquaint his countrymen with any new discoveries that came under his notice in the course of his visit, through the columns of one or other of the Paris technical journals devoted to electricity.

The loss that electrical science has sustained in the death of Alfred Niaudet is great, and will be felt far beyond the shores of his own country. His capabilities may be estimated from the work he accomplished during his short life, of which we have here given but a faint outline.—*The Electrician.*

THE MONTGOLFIER BROTHERS.

To gratify the interest excited by the recent Montgolfier anniversary in France, we extract from the oration of M. Dupuy de Lome delivered on that occasion a few notes upon the lives and charac ters of these remarkable men.

Joseph Montgolfier was born at Vidalon-les-Annonay in the commune of Davezieux upon the 26th of August. His father, Pierre Montgolfier, was a large manufacturer of paper, and was esteemed by his friends and his numerous workmen for his sweet disposition, his unaffected piety and virtue. His son Joseph early manifested an intractable disposition and rebelled against the stereotyped routine of the schools, and full of his own ideas and d esigns escaped from college before he was 13 years old. The parental authority enforced his return, and compelled him to follow for some time the distasteful course of theology. A peddler of books presented him with an elementary work on arithmetic which threw him into the wildest delight. He followed by original methods the lines of mathematical thought indicated in this small treatise, and devised a system of calculation which be always afterward employed.

After leaving college he devoted himself to the study of physics and chemistry and visited Paris to see and hear the great teachers of the schools. He soon entered into partnership with his father and greatly extended his business, opening new works. His inventive genius led him into fruitless and expensive experiments, and his good nature was repeatedly imposed upon by his designing debtors, one of whom by some trick secured his temporary imprisonment in revenge for an attempt made by Montgolfier to secure his just debts. Nothing, however, disquieted him, and he daily pursued his thoughts, which led him into the deepest moods of abstraction and forgetfulness. So exhausting did these mental labors at times become that he would faint, upon returning to consciousness of things around him. In the management of his various establishments he walked from place to place and pursued during these pedestrian trips his projects of new inventions increasingly.

He invented a pneumatic engine for rarefying the air in the moulds, stereotypes for printing, various processes for the making of colored papers, a fire pump, and many other devices which an unconquerable repugnance to writing prevented him from committing to paper. He soon received an additional encouragement in his inventive recreations by association with his younger brother Etienne.

Etienne Montgolfier was born at Vidalon-les-Annonay, on the 7th January, 1745. He had studied at Paris at the College of Saint Barbary and was the esteemed pupil of the architect Soufflat. He had designed a church, a manufactory, had become associated with an army engineer, and was recalled from Paris at a time when a most promising career opened before him in the French capital.

The two brothers Joseph and Etienne found each other congenial companions, and entered together into new projects for utilizing natural forces in the machinery of their paper mill.

Joseph had no desire for book study, but elaborated in his own mind the principles of physics, which he divined by a sort of instinct. The conservation of force, the conversion of arrested motion into heat, seemed to have been understood by him; and Seguin, his nephew and pupil, who afterward became one of the most illustrious of the corresponding members of the Academy of Sciences, states in this connection principles involved in his discussion of the transmission of force, of heat, of light, and electricity, then altogether new, which his uncle professed. In fact, in a note of Joseph Montgolfier, inserted in 1803 in No. 72 of the *Journal des Mines,* we read this sentence: "The force of which a body is possessed cannot in any case be annihilated." He invented a hydraulic press, ignorant of the previous designs of Pascal on this matter, and invented a piece of hydraulic machinery now familiar but which caused the greatest astonishment to the philosophers of his day—the hydraulic ram. The raising of water to heights had previously been effected by utilizing the force of a current of water acting upon water wheels, which in turn put in motion hoisting apparatus. This was costly, inefficient, complicated, and irregular in its action. Joseph Montgolfier saw that if, at the extremity of a strong tube more or less long and conducting water from a higher source, the outlet was suddenly closed, it would only be necessary to have the water force open another exit into a vertical pipe, for it (the water) to rise in this latter pipe in such quantity and to such a height as represented the power of work in the running water in the first conduit. This was the principle of his hydraulic ram, one of the most interesting episodes of his industrious and fruitful life.

But it was his demonstration of the possibility of aerial navigation which most astounded his contemporaries and raised a storm of enthusiasm almost indescribable. He was not the first to work at this difficult problem. A Jesuit, Lana in 1670, and more successfully P. Gallieu, a monk, in 1755, had written on this subject, but their studies resulted in nothing, partaking more of the character of idle vagaries. Joseph Montgolfier in 1782 at Avignon, alone in a tavern, at a time when the allied armies laid siege to Gibraltar, was thinking whether or no soldiers could not be transported upon the famous stronghold through the air. He looked at the smoke rising up the chimney, and in an instant designed the *balloon.* He made a parallelopipedon of silk, inclosing 40 cubic feet, weighted it at the bottom, inflated it with the smoke and hot air from burning paper, and saw it rise to the ceiling, to the astonishment of his hostess. He wrote at once to his brother Etienne at Annonay: "Get ready silk and cord and ropes. You shall see the wonder of the world."

Returning, he explained his views to his brother, who, wild with joy, entered into the new ideas with enthusiasm. The brothers first sent up a small balloon, then a second containing 650 cubic feet. On the 5th of June, 1783, a public exhibition was given at Annonay in the presence of a great concourse of people, and a balloon 110 feet in circumference, weighing about 500 pounds, was filled with hot air and finally loosened; rising it sailed away horizontally, and after 10 minutes slowly descended. It was made of packing cloth doubled with paper sewed upon a net of thread. It was almost spherical, with a short neck, which was stretched open by a frame which acted also as ballast, and its capacity was 22,450 cubic feet. Several important conclusions flowed from this experiment. Once inflated, the balloon displaced a weight of air equal to 2030 lb. Now, the machine in all weighed 500 lb., and it was proved that it was necessary to retain it on the earth, to exert a force equal to 490 lb. more. Hence it follows that the weight of the gas contained in the balloon was only 1040 lb., or very nearly one-half the weight of the air displaced. It was hence concluded that it was not air only which had risen from the fire below it, as, to have expanded the air sufficiently to have satisfied the above figures, it should have been raised in temperature to 273° Cent., which certainly was not done. The fire was made of straw and linen rags.

Hydrogen had been discovered by Cavendish a few years before; its lightness was known; the above considerations pointed to it as a useful agent in balloon making. Charles, a physicist, and Robert, a mechanic, constructed a balloon of silk coated with gum and inflated with hydrogen, which ascended in Paris the 27th August, 1783.

On the 19th of September Etienne Montgolfier after a variety of accidents made a successful exhibition of the new marvel at Versailles before the King, the members of the Academy, and a multitude of spectators, who covered every available place within sight of the spot whence the balloon carrying a cage containing a sheep, a cock, and some other animals ascended.

The next step was to provide means for the ascent of human observers in this aerial ship. For this purpose Etienne constructed a balloon 45 feet in diameter and 70 feet high; beneath the neck was a willowware basket in the center of which was an iron receptable where the fire was made, which as it was increased caused the balloon to ascend more rapidly, and as it died out permitted it to descend. On the 15th of October Pilastre du Rozier made an ascent, and after him Giraud de la Villette and the Marquis of Arlandes. On the 21st of October another ascent was made, and the delighted navigators, after rising 2202 feet, floated away and landed in Fontainebleau, having traveled 24,000 feet, the first considerable voyage made by men in a balloon.

Other developments of the new idea followed. It is needless to relate them; its practicability was demonstrated, and it brought upon its inventors the Montgolfier brothers a cloud of honors and testimonials. Charles and Robert gave the balloon a scientific importance when on the 1st of December, 1783, they rose before the astonished gaze of thousands in a balloon furnished with the following accessories: a valve for letting the gas escape when descending, ballast to regulate or modify the motion up or down of the balloon, the thread net inclosing the balloon without being attached to it, lending itself to its dilatations and contractions and holding the boat or basket for the aeronauts, the covering of India-rubber applied to the surface of the balloon to retain the gas, the use of the barometer to determine altitudes.

The Montgolfier brothers survived the revolution. Etienne died the 2d of August, 1799, at Serrière, at the age of 54; Joseph survived him, was decorated by Napoleon I. at the institution of the order of the Legion of Honor, became Administrator of the Conservatory of Arts and Trades, member of the Consulting Bureau of Arts and Manufactures, and of many other societies. He worked unceasingly, and death

came to him amid his labors. He was struck by apoplexy in 1809, and died the 26th of June, 1810, at the age of 69.

[An engraving of the statue erected to the memory of the Montgolfier brothers at Annonay, France, in August, 1883, will be found in SCIENTIFIC AMERICAN SUPPLEMENT No. 406, Oct. 13, 1883.]

THE MANUFACTURE OF BALLOONS AT PARIS.

THE taste for aeronautics, an art which is essentially a French one, is daily increasing, and balloon ascensions are becoming so numerous that it may be said without exaggeration that there occurs, on an average, one every day in France alone, or about 360 a year! This aerial sailing has given rise to a special manufacture which belongs to the numerous classes of Parisian specialties, but which is very little known to the public. We shall give our readers on the present occasion a few unpublished details in regard to this subject, by describing the most important factory of the kind in Paris, this being the one directed by Mr. H. Lachambre at Vaugirard. The manufacture of balloons may be divided into three distinct categories, to wit:

1. That of balloons of large dimensions (from 200 to 3,000 cubic meters), of varnished percaline or silk, designed for the ascensions of professionals, amateurs, or aerial explorers. Along with these gas balloons we may mention Montgolfiers, or hot-air ones, which are still manufactured, which are made of serge or linen cloth. One of these balloons, in order to raise a man, must have a volume of about 1,200 cubic meters. With hydrogen gas, a balloon of 200 cubic meters possesses superior ascensional power.

2. That of small, gold beater's skin balloons having the form of human beings or of animals, and designed for amusing the public during fêtes. These balloons are also made in spherical form, of 50 liters to one cubic meter capacity or more, and may then be employed as pilot balloons for aeronauts, or as balloons for making observations on aerial currents by meteorologists.

3. That of paper Montgolfiers of from one to ten meters in diameter, designed to be expanded with hot air and sent up to wander in space.

4. That of toy balloons of rubber, essentially designed for large stores, such as the *Bon Marché*, the *Louvre*, etc.

This last manufacture is a special one, and we shall not speak of it at present, but reserve it for a future occasion.

We shall also have to content ourselves with a mere mention of the manufacture of large balloons for aerial excursionists, promising to treat this important subject hereafter with all the details that it deserves. It will suffice to say that the production of these is becoming very important, and that the Vaugirard factory has already manufactured since the beginning of this year (1883) eighteen balloons of from 200 to 3,000 cubic meters capacity, among which we may cite "La Ville de Boulogne," by means of which Mr. L'Hoste accomplished his remarkable voyages over the North Sea and crossed the Strait of Dover; a balloon of 500 cubic meters, made under the direction of Mr. Albert Tissandier; a large balloon of 3,000 cubic meters for Mr. Eloy; and a cylindrical balloon of the same size made for a Brazilian, Mr. Ribeiro, who recently took it to his country for experimentation.

We now come to the curious manufacture of gold beater's skin balloons and paper Montgolfiers. Every one has seen the former of these in toy shops. When inflated they represent Punchinellos, Normandy country women, dogs, cats, fishes, tigers, elephants, crocodiles, gendarmes, etc. When filled with illuminating gas or hydrogen they slowly rise into the air, and the figures, on being wafted along by currents of wind, sometimes assume postures that are truly funny, much to the joy of the spectators.

Is the importance of such a manufacture for a moment doubted? There are sent out from the Vaugirard factory every year from 6,000 to 8,000 of these balloons; and the fête of July 14 uses throughout France from 1,500 to 2,000 of them. For the small paper Montgolfiers the figures reach about the same proportion.

The raw material that goes to form these grotesque balloons is gold beater's skin, or the lining of the large intestine of the ox. This is preserved in salt. When it is to be used, it is soaked for 24 hours and afterward washed in several waters. It is then selected or sorted. The strongest and thickest membranes serve for simple objects, while the finest ones are employed for balloons and double objects. The first pattern, designed to convert the membrane into a grotesque balloon, is modeled in clay by a sculptor, and this is afterward reproduced in plaster and in several pieces. A pulp made of paste board is then squeezed into the matrix of plaster, and when it becomes dry the parts are united so as to form a reproduction of the original model.

Over this model thus prepared two or three thicknesses of the membrane are stretched and allowed to dry. After complete desiccation has been effected, the model is taken out. This operation, which is very difficult to perform, consists in breaking up the cardboard and taking out the fragments through a small aperture in the membrane. This aperture is afterward closed with a piece of dry membrane, the tube serving to introduce the air is fixed in place, and the balloon is inflated by means of a bellows. This first pattern, called the "form," is covered with a coating of varnish which renders it impermeable and proof against moisture. This form when dry is slightly oiled, and when inflated with air serves to shape the commercial articles over.

The membrane, spread out and stretched over the frame by means of a pair of scissors, adheres at the edges when the pieces are overlapped by a centimeter or two. The form having been entirely covered, the tube is affixed and the whole is left to dry. When the desiccation is complete the membrane is colored with tints, prepared with gum water or varnish.

It now only remains to take out the form. This is done by blowing between the latter (which has previously been emptied of air) and the superposed balloon. The form is then removed through the small aperture, the latter is closed, and the object is finished.

So much for gold beater's skin balloons.

Montgolfiers are made out of such fine papers as are found in commerce. They are cut out upon a table by means of a knife, and of a pattern that has been laid out by the usual geometrical methods.

The pieces are then properly pasted together, the orifice at the top of the balloon is closed by a paper circle, to which is affixed a suspension ring, and the bottom is provided with a wire hoop.

Our engraving represents the works of Mr. H. Lachambre at Vaugirard, drawn from nature. In appearance they are very picturesque and truly curious. While the large balloons in course of construction are inflated with air in order that the varnish with which they are covered may dry, and while workwomen are sewing together parts of others, we see gold beater's skin balloons being made all around the factory, we see gendarmes being shaped, and we might almost imagine ourselves in a dissecting room. But, far from destroying by the analysis of the anatomist the corpse of a living being the workwoman is forming by synthesis an animal or an artificial personage that will need but a few hectoliters of hydrogen to give it life and set it hovering about in space.—*La Nature.*

A BALLOON MANUFACTORY AT PARIS.

NICKEL has been found in Nevada and Oregon in paying quantities. From the Nevada mines the ores yielded 29 per cent.

NEW APPARATUS FOR THE MANUFACTURE OF HYDROGEN.

AT the beginning of the present year, in publishing a description of a dynamo-electric propeller designed for an oblong balloon, I made known to my readers the aerostatic works that we (my brother Albert and myself) had founded at Paris-Auteuil.

Since that period, while my brother has especially devoted himself to the elongated balloon, I have been occupied in constructing an apparatus designed for producing hydrogen on a large scale, in order that the operation of inflating balloons of large size may be performed in a few hours. Well prepared hydrogen gas possesses an ascensional power of 1,180 grammes per cubic meter, while that of illuminating gas is only 730 to 740 grammes for the same volume. These figures suffice to show the advantage that the former possesses over the latter from an aerostatic point of view.

The production of hydrogen on a large scale is not only a subject of interest to aeronauts, but is also of importance to chemical laboratories that are located at a distance from gas works, and to certain industries that make use of the oxyhydrogen blowpipe for melting metals. It is for this reason that I give herewith somewhat of a detailed description of my new apparatus. This latter is constructed upon a principle analogous to that which my lamented master and friend, Henri Giffard, installed in 1878 in the courtyard of the Tuileries, for inflating his great captive steam balloon; but it differs therefrom considerably in its details, and in its mode of construction. In my apparatus, as in Giffard's, the hydrogen is produced through the decomposition of water under the influence of iron and sulphuric acid; but instead of employing a single generator of large size, made of iron plate lined with thick sheets of lead of high cost, I use Doulton earthen pipes, the same as those usually employed for water conduits. These pipes resist the action of acids very well, even when the latter are hot, and on joining them together by means of a special cement, it is possible to use them for making cylindrical reservoirs of large capacity and at a cost much less than that of metallic ones. After experimenting with pipes of small size, I have constructed a generator of 8 Doulton pipes of 0·45 m. internal diameter, and 0·76 m. in length. I thus obtain a column more than 6 meters in height, capable of holding a thousand kilogrammes of sifted iron filings. Four distinct generators, a general view of which is given in Fig. 1, are capable of producing 300 cubic meters of hydrogen per hour, that is to say, of dissolving 1,000 kilogrammes of iron in 1,500 kilogrammes of sulphuric acid diluted with three times its volume of water.

The four generators are identical, and it will, therefore, suffice to describe but one of them. This I shall do as succinctly as possible in referring the reader to the section shown in Fig. 2. The generator, formed of Doulton pipes, is figured at G. The cylinder is closed at the bottom by brick masonry, put in hot with melted sulphur mixed with resin, tallow, and pounded glass. This same cement is employed for luting the joints of the pipes and fastening them together. The lower pipe, that I shall call No. 1, and pipes No. 4 and 6—counting from bottom up—have two branches that permit of their being coupled with the smaller pipes that serve for introducing the diluted acid, for the exit of the liquid charged with sulphate of iron after the reaction is over, and for the exit of the hydrogen gas that has been produced. The generator having been filled with iron filings, the diluted acid is let in through the pipe, A, and enters the lower part of the cylinder. Here it traverses a double bottom, perforated with holes, and rises through the column of iron filings. The hydrogen produced through the reaction is disengaged through the pipe, T, and the liquid charged with sulphate of iron flows into B, through

the U-shaped pipe, B C, and enters a gutter that leads it directly to the sewer. As the flow of water charged with acid is continuous, the production of hydrogen is likewise so, and in measure as the iron dissolves in the lower part of the generator it is incessantly renewed by the reserve contained in the upper part of the pipe. This reserve of iron, which supplies the generator, is placed in an upper metallic tube, the lower part of which, made of copper coated with lead, dips for a few centimeters into the liquid in which the reaction occurs. The solution of sulphate of iron, on escaping at B, therefore, carries along with it no iron filings.

The generator is closed at its upper part by an hydraulic cap, which, in case of obstruction, forms a safety valve. My apparatus, as I have said, comprises four generators, and these are capable, as may be needed, of operating together or isolatedly. It is easy to separate them from the enough for the production of from 350 to 400 cubic meters of hydrogen. While one of the vats is emptying into the four generators, the other may be filled, and so on alternately. The generators are surrounded by a strong framework provided with an upper platform up to which may be hoisted, by means of a tackle, the carboys of acid and the bags of iron filings necessary to supply the apparatus.

The large apparatus just described has been operated on several occasions, and has already furnished gas for three ascensions, which I hope are but the prelude to a new aeronautic campaign.

On the 17th of last August we started from our yard in a spherical silken balloon, of 500 cubic meters capacity, which my brother had had constructed. We both went up at quarter past seven in the evening, and as we passed over Paris its lights were already twinkling by thousands and

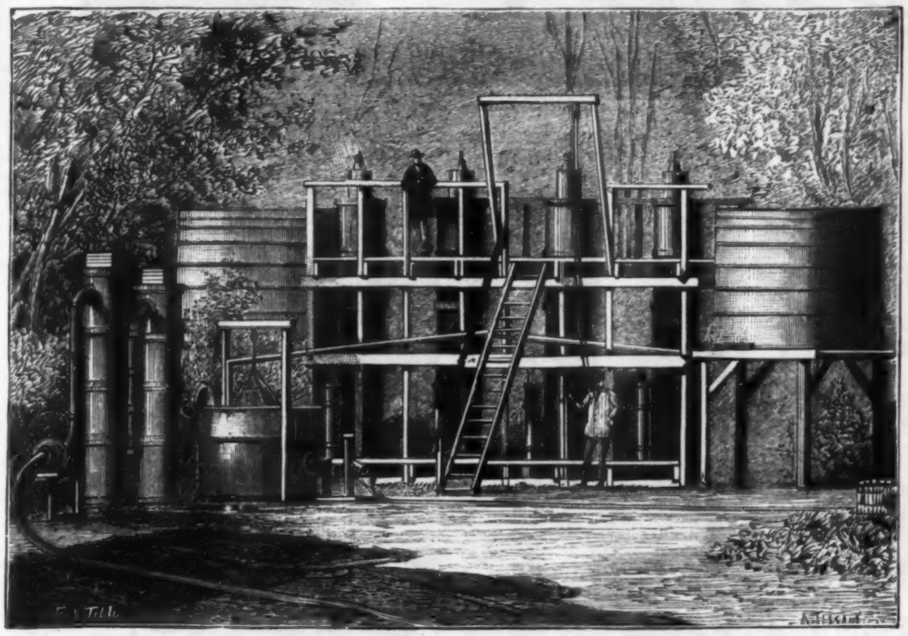


FIG. 1.—GENERAL VIEW OF TISSANDIER'S HYDROGEN APPARATUS.

circuit of hydrogen pipes by means of cocks of 0·08 inch internal diameter.

It thus becomes possible to charge a generator with iron filings, to proceed to clean it in case the pipes get obstructed, etc., without interrupting the production of the other three. The hydrogen gas, produced by an energetic reaction, is disengaged with torrents of steam, and, besides, as it is slightly acid, it it necessary to cool it and wash it. My washer, which is nearly like Giffard's, is shown at L. The gas enters at the bottom of a quantity of water which is continuously renewed by a constant flow, and, traversing this, becomes divided through a large number of perforated tubes branching from the inlet pipe. After being washed, it traverses two purifiers, EE', filled with caustic soda and chloride of calcium, and finally passes through a glass globe, H, containing a hygrometer and a thermometer that indicate presenting the aspect of stars, such as are to be seen in a cloudless southern sky. At the surface the wind was quite feeble, and at a height of from 1 500 to 1,800 meters it was absolutely null, and here the balloon remained immovable over the same point. After a voyage of about two hours we passed over the city of Lagny, at a height of about 250 meters, when our balloon was caught by a superficial current that carried it along toward the north. It was ten minutes past nine, and nearly as dark as pitch, when we gently touched the earth on the brink of the Marne, in the neighborhood of Annet (Fig. 3). As the balloon was impermeable it was fastened tightly, and left inflated until the following day. After passing the night at an inn in the vicinity, we proceeded to let out the gas.

On the 28th of August we set a single one of our generators in operation in order to inflate a small balloon of 200

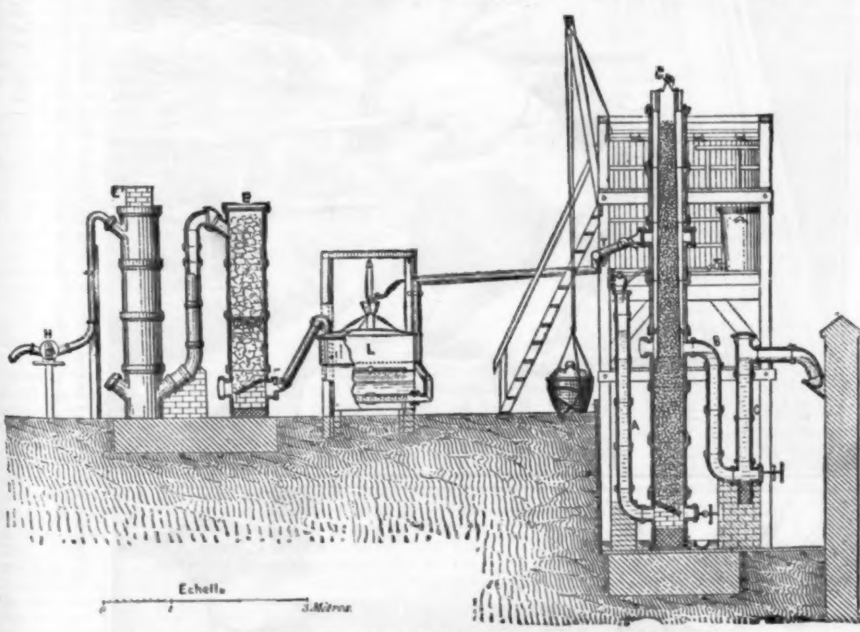


FIG. 2.—SECTION OF TISSANDIER'S HYDROGEN APPARATUS

whether it has been properly dried and cooled. Under such circumstances we obtain a gas that is almost completely dry, and that has an ascensional power of 1,190 grammes per cubic meter—a figure that has never heretofore been obtained in aerostatic preparations made on a large scale. After traversing the glass globe, H, the gas enters the balloon through the intermedium of an ordinary inflating pipe.

The four generators of my apparatus are supplied with the acid that sets them in operation by two large reservoirs of 8 cubic meters capacity (Fig. 1), which consist of vats made of very thick wood, provided beneath with four Doulton earthen cocks that permit of the four generators being all supplied at once. Each of these reservoirs is capable of holding 53 carboys of 53° sulphuric acid, or 3,000 kilogrammes diluted with 6,000 of ordinary water. There is, in each of them, a reserve supply capable of furnishing c. m. capacity, in which a young professional, Mr. Auguste Gandron, a pupil of Mr. H. Lachambre made a very good ascension, and one that permitted once again of ascertaining the presence of those superposed aerial currents that are so frequent in the atmosphere. The balloon, ascending at half past five in the evening, took at the start at two different altitudes, two opposite directions. The lower current was northeasterly and the upper one came from the south. The latter carried the balloon toward the north, where it landed, at a quarter before seven, at Monsoult, beyond the forest of Montmorency.

On the 10th of September my brother started alone in this same small balloon, which, by means of a single generator, was easily inflated in the space of three hours. The start occurred at quarter past two, and the balloon, after sailing over the woods of Boulogne, Argenteuil, Houille, and Pontoise, and after reaching an altitude of 1,300 meters, touched earth at five o'clock in the evening in the department of Oise.—*Gaston Tissandier, in La Nature.*

MANUFACTURE OF CAMPHOR IN JAPAN.

Report by CONSUL JONES, of Nagasaki.

THE manufacture of camphor is an important industry on the island of Kiu Shiu (Kew Shew).

From the port of Nagasaki there were exported, in the year 1882, 15,186·18 piculs, valued at 227,792 dollars. A picul is 133⅓ pounds. From other ports of the island, not yet opened to foreign trade, a large quantity was shipped by native merchants in native vessels to Shanghai in China, and Hong Kong, whence it finds its way to India and England; little or none of it is exported to the United States. The camphor tree grows abundantly all over this portion of Japan. It is found alike on high elevations and in the valleys and lowlands. It is a hardy, vigorous, long-lived tree, and flourishes in all situations.

Many of these trees attain an enormous size. There are a number in the vicinity of Nagasaki which measure ten and twelve feet in diameter. The ancient temple of Osuwa at Nagasaki is situated in a magnificent grove of many hundred grand old camphor trees, which are of great age and size, and are still beautiful and vigorous. I am told that there are trees in other places in Kiu Shiu measuring as much as twenty feet in diameter. The body or trunk of the tree usually runs up twenty and thirty feet without limbs, then branching out in all directions, forming a well proportioned, beautiful tree, evergreen and very ornamental.

The leaf is small, elliptical in shape, slightly serrated, and of a vivid dark-green color all the year round, except for a week or two in the early spring, when the young leaves are of a delicate tender green. The seed or berry grows in clusters and resembles black currants in size and appearance. The wood is used for many purposes, its fine grain rendering it especially valuable for cabinet work, while it is used also for ship-building. The roots make excellent knees for ships.

I have sent many seeds of the camphor tree to the United States, in the hope of adding to our own arboriculture.

In the manufacture of camphor the tree is necessarily destroyed, but, by a stringent law of the land, another is planted in its stead. The simple method of manufacture employed by the natives is as follows:

The tree is felled to the earth and cut into small pieces, or, more properly speaking, into chips.

A large metal pot is partially filled with water and placed over a slow fire. A wooden tub is fitted to the top of the pot and the chips of camphor wood are placed in this. The bottom of the tub is perforated so as to permit the steam to pass up among the chips.

A steam-tight cover is fitted on the tub. From this tub a bamboo pipe leads to another tub, through which the inclosed steam, the generated camphor, and oil flow. This second tub is connected in like manner with a third.

The third tub is divided into two compartments, one above the other, the dividing floor being perforated with small holes, to allow the water and oil to pass to the lower compartment. The upper compartment is supplied with a layer of straw, which catches and holds the camphor in crystals in deposit as it passes to the cooling process. The camphor is then separated from the straw, packed in wooden tubs of 133⅓ pounds each, and is ready for market.

After each boiling the water runs off through a faucet, leaving the oil, which is used by the natives for illuminating and other purposes.

WYOMING OIL.

IN the Sweetwater country in Wyoming, there are large deposits of petroleum. Dr. G. B. Graff, of Omaha, several years ago improved the springs there by digging some reservoirs to collect the oil and store it to hold for market. This oil has been used for several years for lubricating axles and machinery on the Union Pacific, and has gained a fine reputation for its excellent qualities. To make the oil property profitable, Dr. Graff has been engaged in organizing

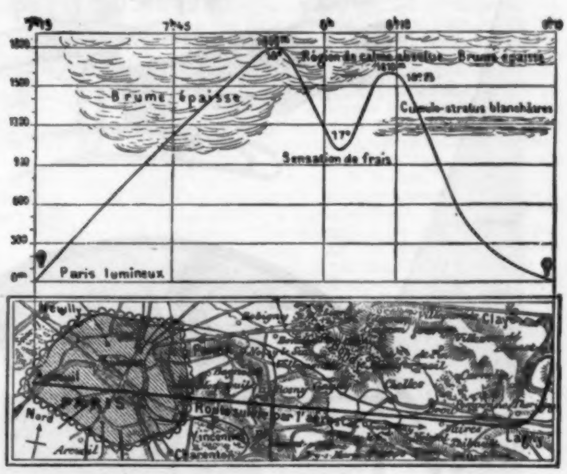
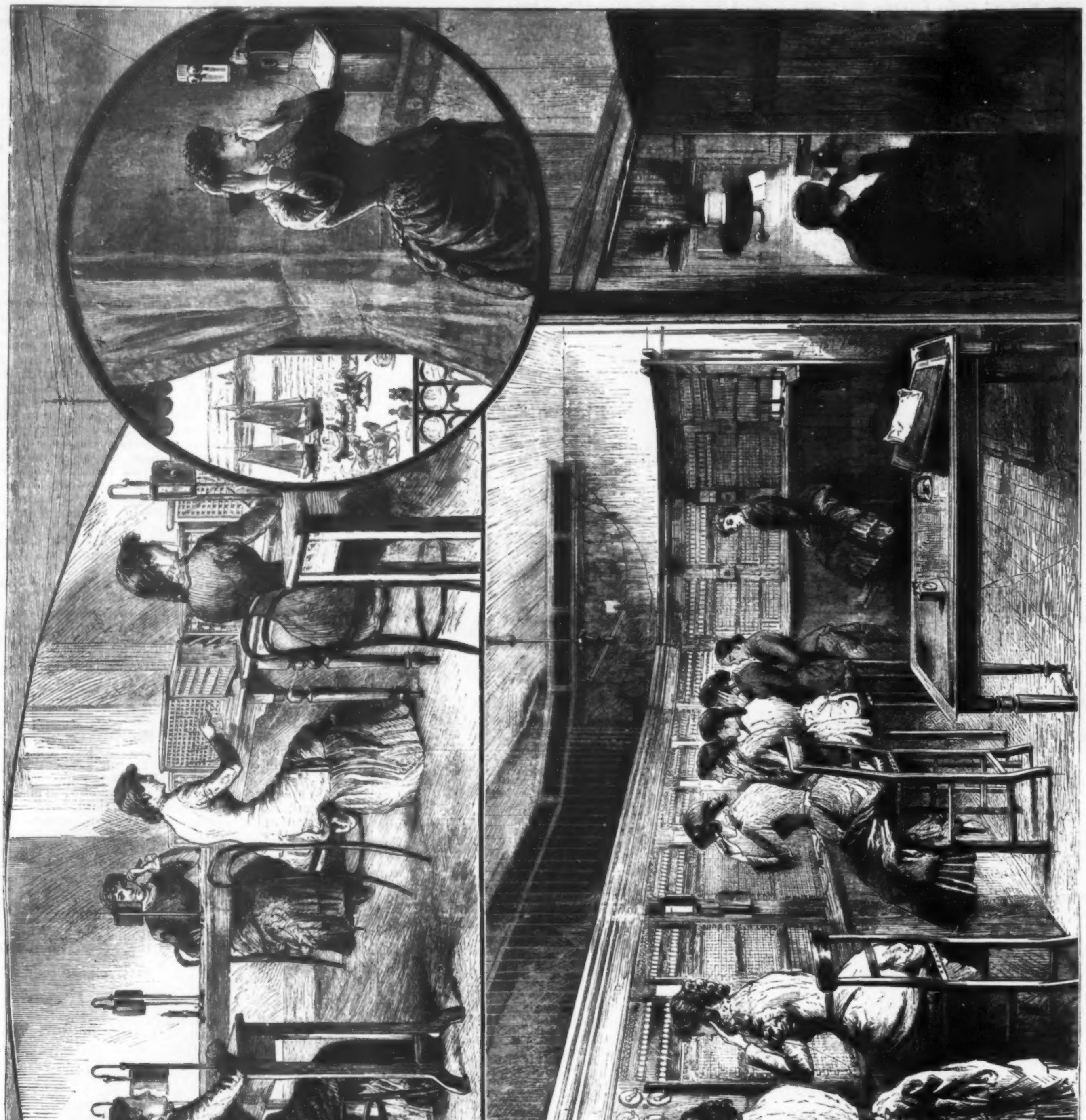


FIG. 3—DIAGRAM OF A BALLOON ASCENSION MADE BY THE TISSANDIER BROTHERS, AUG. 17, 1883.

capital to develop it, and the result of his labors are set forth in the Omaha *Bee*, as follows:

"Dr. Graff, of Omaha, who is engineering the development of the oil field of Wyoming, has returned from a visit to England, where he is supposed to have secured the necessary capital for active work. The company, of which he is the working head, proposes to erect a large refinery at Point of Rocks Station, which is situated sixty-nine miles south of the oil-fields. This will have a capacity of 3,000 barrels of refined kerosene per day. A pipe line will be built to the wells, at a cost of $225,000, to convey the crude oil, and bull trains will also run between the wells and Point of Rocks, transporting lubricating oil.

"The oil, in transit through the pipe line, will have to be carried over an elevation of 2,000 feet, but heavy pumps will do the work. Dr. Graff expects to have the pipe line



1. Switch Room of a Central Office Worked by Slipper Board System.—2. Switch Room of a Central Office Worked by Peg Board System.—3 and 4. Talking Between London and Brighton.—5. Head Central Office of the United Telephone Company, Coleman Street.—6. Reporting by Telephone from the House of Commons to the "Times" Office.

THE TELEPHONE EXCHANGE IN LONDON.

in operation this fall, and the refinery under roof. A Pennsylvania expert, who recently examined these oil fields, thinks that the oil, if found in the paying quantities he anticipates, will be used principally as fuel for smelting the ores which are found in such abundance in the mountains of the Territory. Smelting is now a very expensive process, as coke ranges in price from $25 to $80 per ton. Petroleum produced at the price now ruling in this region would cost but $7 per ton, and a ton of petroleum would do about three times the work of a ton of coke. It would undoubtedly, in time, prove a vigorous competitor of Pennsylvania oil for lighting purposes, as refined petroleum now sells in the Territory at 20 cents per gallon. With continued growth of the West, there will be no lack of a home market for all that can be produced.

FILTRATION OF VERY MINUTELY DIVIDED PRECIPITATES.

By LECOQ DE BOISBAUDRAN.

IT is known that certain precipitates, such as sulphur, in emulsion pass through filter paper. The author often employs a method which in many cases obviates this inconvenience, and which, to his knowledge, has not yet been made public. Filter paper is boiled with *aqua regia* until the mass is fluidified; it is then poured into a large quantity of water, and the white precipitate formed is washed by decantation. To render the texture of a filter very compact it is filled with this material, previously stirred up in water, so as to form a very thin paste, and allowed to drain. The paper is thus covered with a layer, which obstructs its pores. Or a little of the same pasty matter may be mixed with the liquid to be filtered.

THE TELEPHONE EXCHANGE IN LONDON.

ONE of the most extraordinary feats which the modern appliances of electricity have now made easy of performance is that of enabling two persons at a distance to talk together—not by means of the deflection of a needle to the right or to the left, but by the actual reproduction of the voice itself. We illustrate the manner in which the telephone is put in practical use not only in London, but in all the chief European cities, and to a much greater extent across the Atlantic. The system in question is known as the "Exchange." The wires, to which are attached the instruments in the houses or offices of subscribers to the company who have the monopoly of the instruments, all lead to a central office known as the Exchange, and there any one correspondent can be "switched" or placed into communication with any other subscriber, being thus able to chat or transact business with some thousands of persons. Each subscriber is allotted a particular number by which he is known, and when wanting to speak with any correspondent, he rings the Exchange up, by pressing a button on his instrument. This causes an indicator bearing his number to drop in the Exchange room. The attendant in charge, ordinarily a female clerk, then switches his line on to her telephone and answers him. When he has told her the number he requires, she switches the two numbers through to each other, thus placing the two persons in communication.

The two Exchanges we illustrate are worked on slightly different systems.

No. 1 shows one worked with a switch-board called a slipper-board. The attendant seated in front of the switchboard has, in this case, nothing to do but to switch the subscriber, in the first instance, through to the attendant at the table, who answers him, and, ascertaining the number he requires, calls it to the switch-board attendant, who connects the two subscribers' lines together by means of a cord with plugs on the ends, the cords containing a flexible conductor. There are two of these slipper-boards shown, each of which is capable of holding one hundred and fifty subscribers; the indicator boards being placed on both sides of them. At the tables where the attendants who answer the subscribers are sitting the transmitters are shown suspended from hooks.

No. 2 shows an Exchange worked on a different principle. The switch-board, in this case, is called a peg-board, being worked by means of small pegs, in the place of cords and plugs as in the former case, and each attendant performs the double duty of answering and switching the subscribers' lines. The indicators are shown in the upper part of the boards, and the peg-boards below them. On the third set of indicators, one will be seen to have dropped, and the attendant at the board is answering the subscriber who has rung her up. Just beyond this set of indicators some circular switches are shown, which are used for connecting subscribers at night.

No. 5 shows the Central Exchange in Coleman Street, and the frame on the roof, on which upward of 500 wires are fixed, and are carried into the Exchange in a room below.

No. 6 depicts a telephone at the House of Commons, by means of which the speeches are transmitted by the reporter direct to the compositor, who is supplied with two small telephones, held to his ears by springs, his hands being entirely disengaged to work the composing machine.

Nos. 3 and 4 are prospective sketches of two persons talking by telephone between Brighton and London, which towns will soon be connected. Experiments have already been made between these stations by means of the ordinary telegraph wires, and proved to be in every way successful. A regular line of telephone wires is now in course of erection. The instruments which are shown being used for this purpose are the same as those already used by all the subscribers and exchanges, viz., the Blake transmitter and the Bell telephone receiver. This transmitter, into which the speaker talks, is composed of a diaphragm vibrating against a small platinum bead, which presses against a button of carbon. Through these a current of electricity is passed. Any movement of the diaphragm of the transmitter, such as the vibration of sound of speech, causes the platinum bead to press into the carbon, which thereby alters the current of electricity. This alteration is carried by the wire to the receiver at the other end, and causes its diaphragm to vibrate in a precisely similar manner as that of the transmitter, and so reproduce the exact sounds. The telephone receiver contains a diaphragm, opposite the center of which is a magnet with a small coil at one end; the current from the transmitter passes through this coil, and by its variation causes the diaphragm of the receiver to be vibrated.

There are now in London over 3,000 subscribers to the United Telephone Exchange, and the "calls" are said to be some 21,500 daily; allowing for a question and answer to each, this makes a total of 43,000 messages for every day.—*London Graphic.*

A HORIZONTAL CAPILLARY ELECTROMETER.

By M. CH. CLAVERIE.

A GLASS tube, V, with an internal diameter of from 0·005 meter to 0·006 meter is drawn out by the blow pipe so as to give a slightly conical capillary tube, having an internal diameter of 0·001 at the most. The capillary portion is curved as shown in Fig. 1, and the whole is fixed on a vertical board supported by a foot piece with three leveling screws, together with a second tube, V', closed at its lower end, holding a little mercury and acidulated water, in which the end of the capillary tube is immersed. The space A to B is divided into millimeters; *a* and *b* are platinum wires; these are connected, mercury is poured into V, the apparatus is inclined until the mercury flows drop by drop into V'; the apparatus is then righted until A B is about horizontal, and little by little more mercury is poured into V until the mercurial meniscus* in A B is close to the end, B, near V'. This is the zero of the apparatus. If now *a* be made negative to *b*, the meniscus will retreat from B toward A, and the displacement is always the same for the same electromotive force if the apparatus is well made. But it is rare for an apparatus

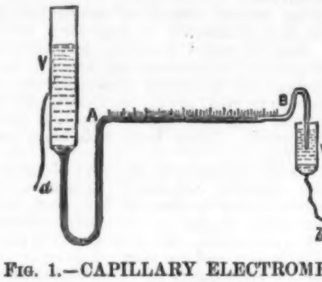


FIG. 1.—CAPILLARY ELECTROMETER.

constructed without special precaution not to have several zeros, and for the same electromotive force not to produce several different displacements. If the variation in diameter of the capillary portion is studied by sending through it a globule of mercury, it will be noticed that it is as a rule very irregular. I only keep tubes the diameters of which vary over a certain length as the ordinates of a straight line, and it is the corresponding portion of the tube which serves to form the rectilineal and horizontal part, A B, of the electrometer.

The heights of mercury that the meniscus placed at different points of the tubes can support are according to Jurin's law, in inverse ratio to the diameters of the tube, and accordingly vary as the ordinates of a hyperbolic curve, which does not materially differ from a straight line in the part corresponding to the capillary branch, A B.

Let us suppose that A B makes an angle, *a*, with the horizon by sloping downward from A. From the different points of A B (Fig. 2) draw verticals on which set off lines

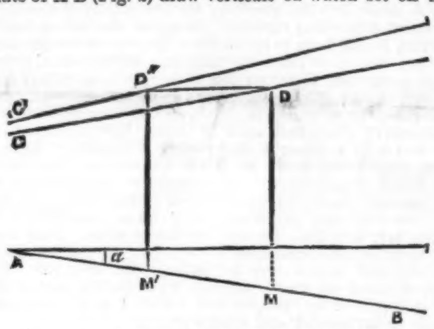


FIG. 2.—CAPILLARY ELECTROMETER.

equal in length to the heights of mercury that the meniscus placed within these points of the tube can support, the wires, *a* and *b*, being in connection.

The ends of these determine a line, C D. If between *a* and *b* we cause a difference of potential, *e*, the heights of mercury sustained by the meniscus increase by a fraction of themselves proportional to *e*, and we have a fresh line, C' D', which meets A B at the same point as C D. If the meniscus is at first in M, it reaches a point, M', such that the ordinates of C' D' and C D passing through M' and M are equal.

If l represents the length, A B, a and b the heights of mercury indicated between A and B by the meniscus when $e = 0$, x and x' the distances of M and M' at the point where A B meets C D and C' D', d the displacement M M',

$$d = \frac{k\,(b-a)\,x'\,e}{b-a-l\sin a} = \frac{k\,(b-a)\,x\,e}{(b-a)\,(1 \times ke) - l\sin a}.$$

The variations of x are always small enough to enable us to consider x' as materially constant; for example, x being equal to 4 *m* the greatest difference between x' and x will be 0·20 *m*. We see, therefore, that the displacement, d, is proportional to e. Further we see that the sensitiveness increases with a up to the point where $b - a - l \sin a = 0$; for this value of a, C D would be horizontal, and the apparatus would no longer have a zero. For a higher value of a, it will be readily seen that only a position of unstable equilibrium would remain for the meniscus, and that if it were brought to a certain point in the tube it would, in general, oscillate, now to this side, now to the other, up to a point where it would leave A B.

If the tube be inclined by elevating the end, B, the sensitiveness is decreased. Therefore, by means of the leveling screws, the sensitiveness of the apparatus can be determined. With a displacement of 0·150 m. for an electromotive force of one volt, the zero is perfectly fixed, and the stoppages of the meniscus are very well defined.—*Journal de Physique; The Electrician.*

* The curved extremity of a mercury column is called the meniscus.

THE ARTIFICIAL LIGHT OF THE FUTURE.

THE following, from the *Gentleman's Magazine*, is given for what it is worth: "The ordinary light of the future must be cheap. In order to be cheap it must not be a result of physical or chemical violence, as all such violence is destructive of material, and consequently expensive. This is the vital and necessary defect of the electric light. Let us rather study the machinery of the glow worm than that of the thunderstorm. Let some industrious German collect a small quantity of glow-worms, and weigh them carefully, then measure the amount of light they emit in a given time without taking food, and then weigh them again. I have little doubt that he will find that their consumption of material in the production of a given amount of light is marvelously smaller than that demanded by any of our methods of chemical violence. May we not isolate these hydrocarbons and aldehydes (turpentine and incipient vinegars), and make them phosphorize, by the aid of alkalies and oxygen rendered active, or ozonized, as ordinary atmospheric oxygen is by mere contact with the vapor of such bodies? The faintness of phosphorescence may be suggested as an objection; if so, let the objector capture a glow-worm, measure the dimensions of the little specks that form its lamps, then put it in a fern-case and observe the illumination of the fronds. Now, suppose a room to be hung with curtains dipped in a solution of glow-worm fuel, so that every fiber of the drapery shall radiate as much light as a corresponding surface of the glow-worm lamp. Such lovely radiance, diffusible at pleasure, would by comparison render the electric light a glaring, intolerable barbarism. Here, then, is a magnificent field for research. The gate is opened—it may be entered at once; and step by step, little by little, in ever-widening area, it may be explored with definite promise of rich fruits; their possibilities of attainment being demonstrated by the achieved success of the humble glow-worm."

APPARATUS FOR REGISTERING AUTOMATICALLY THE STRENGTH OF EARTH CURRENTS.*

THE apparatus was designed so that by simply shunting it into the circuit of a telegraph wire a diagram of the varying intensity of the earth currents should be traced out. Owing to these currents being usually very weak, it was not possible to employ any mechanical arrangement, and recourse was had to photography. The plates used—bromide of silver gelatine plates—being excessively sensitive, all extraneous light is carefully shut out by inclosing the whole apparatus in a wooden case. The general arrangement may be seen from Fig. 1.

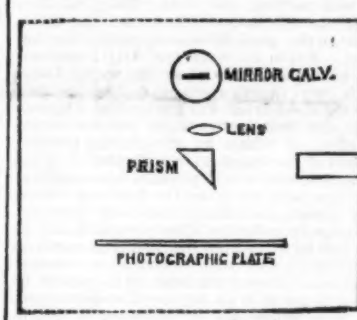


FIG. 1.

A bundle of rays from the lamp passes through a small aperture in a diaphragm closing the end of the tube, and, after traversing the latter, strikes a prism, from which it is reflected on the mirror of a Siemens dead-beat galvanometer. The reflected ray from the mirror is focused by the lens on to the vertical screen supporting the gelatino-bromide plate. The plate is placed in a groove in a wooden box before beginning the observations; a screen can be slid up and down in the groove in front of the plate, as in an ordinary camera. The experimenter can introduce his hand through an opening covered by a black cloth, and can raise the slide to the top of its frame; it is then allowed to descend regularly and slowly, being controlled by a clock. In front of the slide is a horizontal slit, which allows the ray of light to pass. The descent of the slide is at the rate of about 80 mm. per hour. As the sensitive plate slowly moves downward in front of the slit, the spot of light affects it, and the photograph will show any deflections which the mirror has made to right or left of the medial line. Time signals are given by means of the diaphragm at the front end of the tube; in this diaphragm are pierced three equidistant horizontal holes. Generally the light is allowed to pass only through the center hole; but at fixed intervals of time (say every half-hour) the two side holes are opened, and their images then appear on the photograph on each side of the medial line. It is thus easy to measure the duration of any earth current. Fig. 2 is a facsimile of a curve traced by the apparatus, showing the earth currents on the underground cable between Berlin and Dresden on the morning of 29th September last.

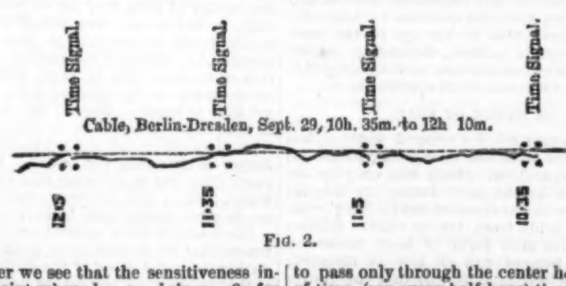


FIG. 2.

* Abstract of an article from the *Zeitschrift fur Instrumentenkunde*, vol. iii, April 1883, in the *Journal of the Society of Telegraph Engineers and of Electricians*, No. 49, 1883.

THE TRANSMISSION OF ENERGY.*

By PROF. OSBORNE REYNOLDS, M.A., F.R.S.

I.

I THINK it may be said that the great interest which the public has manifested in the recent advance in the arts relating to electricity has arisen, in a large measure, from the cry of joy with which Faure's battery was received. "A cry which said, in so many words, here we have at last a means of utilizing our waterfalls and natural sources of power" in a way that may relieve us of all the anxiety about our coal fields. To those who had studied the subject it was evident at the time that this cry was premature. And to some of us, at all events, it seems to be a mistake to encourage false hopes, or, rather, knowingly to base hopes on a false foundation, to hold out as a means of replacing our coal what was, and in all probability, only another means of increasing its rate of consumption, for every step in art which facilitates the application of power must increase the demand on the acting sources.

But this is not all; the exaggerated claim set up for electricity diverted, for a time at all events, attention from the true claim, which would have been sufficient in itself had it not thus been put out of sight. It is not our object at present to save our coal, but to turn it to the best advantage to get the greatest result we can, and if Faure's battery or any subsequent advance in this direction conduces to this, it is no small matter. Now, during the last ten or fifteen years, an entirely new aspect has been given to mechanics by the general recognition of the physical entity which we call energy, in different forms.

We recognize the one thing under different forms in the raised hammer, the bent spring, the compressed air, the moving shot, the charged jar, the hot water in the boiler, and the separate existence of coal, corn, or metals, and oxygen. We see in the revolution of the shafts and the travel of belts in our mills, the passage of water, steam, and air along pipes, the conveyance of coal, corn, and metals, and the electric currents, the transmission of this same thing—energy—from one place to another; and in all mechanical actions we perceive but the change of form of the same thing.

Taking this general or energy point of view, we may get rid of all the complication arising from special purpose, and recognize nothing but the form of energy in its source, the distance it has to be transmitted, and the special form that must be given to it for its application. And this view, although not the best in which to study the special purpose of mechanics or contrivances, is of great importance, inasmuch as it has revealed many general laws, and many fundamental limits to the possibilities of extension in certain directions.

My object in these lectures is to direct your attention to some of the leading mechanical facts and limits revealed by this view.

There is one general remark I would wish to make, by way of caution. I hope nothing I may say will be interpreted by any of my hearers into a prediction as to what may happen in the future. I have to deal with facts, and I shall try to deal with nothing but facts. Many of these facts, or the conclusions to be immediately drawn from them, may appear to bear on the possibilities—or, rather, the impossibilities—of art. But in the Society of Arts I need not point out that art knows no limit; where one way is found to be closed, it is the function of art to find another. Science teaches us the results that will follow from a known condition of things; but there is always the unknown condition, the future effect of which no science can predict. You must have heard of the statement in 1837, that a steam voyage across the Atlantic was a physical impossibility, which was said to have been made by Dr. Lardner. What Dr. Lardner really stated, according to his own showing, was that such a voyage exceeded the then present limits of steam-power. In this he was within the mark, as any one would be if he were to say now that conversation between England and America exceeded the limit of the power of the telephone. But to use such an argument against a proposed enterprise is to ignore the development of art to which such an enterprise may lead.

I wish to do nothing of this kind, and if, in following my subject, I have to point out circumstances which limit the possibilities of present art, and even seek to define the limits thus imposed, it is in the hope of concentrating the efforts of art into what may be possible directions, by pointing out the whereabouts of such barriers as science shows to be impossible.

Although the terms energy and power are in continual, we might always say familiar, use, such use is seldom in strict accordance with their scientific meaning. In many ways the conception of energy has been rendered popular, but a clear idea of the relation of energy to power is difficult. This arises from the extreme generality of the terms; in any particular case the distinction is easy. I was going to say that it is easiest to express this distinction by an analogy, but, as a matter of fact, everything that seems analogous is really an instance of energy. Power may be considered to be directed energy; and we may liken many forms of energy to an excited mob, while the directed forms are likened to a disciplined army. Energy in the form of heat is in the mob form; while energy in the form of a bent spring, or a raised weight, matter moving in one direction, or of electricity, is in the army form. In the one case we can bring the whole effect to bear in any direction, while in the other case we can only bring a certain portion to bear, depending on its concentration. Out of energy in the mob form we may extract a certain portion, depending on its intensity and surrounding circumstances, and it is only this portion which is available for mechanical operations.

THE ENERGY OR POWER OF COAL.

Now energy in what we may call its natural sources has both these forms. All heat is in the mob form, hence all the energy of chemical separation, which can only be developed by combustion, is in the mob form; and this includes the energy stored in the medium of coal. The combustion of 1 lb. of coal yields from ten to twelve million foot-pounds of energy in the mob form of heat; under no circumstances existing at present can all this be directed, nor have we a right, as is often done, to call this the power of coal. What the exact possible power is we do not know, but probably about four-fifths of this, that is to say, from eight to ten million foot-pounds of energy per pound of coal is the extreme limit it can yield under the present conditions of temperature at the earth's surface. But before this energy becomes power, it must be directed. This direction is at present performed by the steam-engine, which is the best instrument art has yet devised, but the efficiency of which is limited by the fact that before the very intense mob energy of the fire is at all directed, it has to be allowed to pass into the less intense mob energy of hot water or steam. The relative intensity of these energies is something like twenty-five to nine. The very first operation of the steam-engine is to diminish the directible portion of the energy of the pound of coal from nine million to three millions. In addition to this there are necessary wastes of directable energy, and a considerable expenditure of already directed energy in the necessary mechanical operations. The result is that, as the limit, in the very highest class engines the pound of coal yields about one and a half millions of foot-pounds; in what are called "first-class engines," such as the compound engines on steamboats, the pound of coal yields one million, and in the majority of engines about five or six hundred thousand foot-pounds. These quantities have been largely increased during the last few years; as far as science can predict, they are open to a further increase. In the steam-engine art is limited to its three million foot-pounds per pound of coal; but gas-engines have already made a new departure, and there seems no reason why art should stop short of a large portion of the nine millions.

Other important natural sources of mechanical powers are energy in an already directed or army form, wind and water power. Here the power needs no development, but merely transmission and adaptation, and hence it has one important advantage over the energy of chemical separation. But there appears to be what are greater drawbacks—in the irregularity of these forces as regards time, and the distribution as regards space. These have both been, and are, good servants to man.

The application of the power of the wind to the propulsion of ships has, doubtless, influenced the economy of the world more than any other mechanical feat; and, not very long ago, water power played no relatively unimportant part of the work of the world. But it would seem that both these have had their day, and are now relegated to work of a secondary kind, not necessarily so. Some further development of art might bring them to a foremost place again, by developing their use to a hitherto unprecedented extent. Hitherto both wind and water have only had a local application—that is to say, they were used where and when they were wanted. Wind was only used in the sailing of ships on voyages, and for mills, distributed so as to be within range of such corn as was too far from water; while water-power, though very valuable to a certain limited extent, when near habitable country, was otherwise allowed to run to waste; and these wastes included by far the larger sources of this power—the larger rivers and waterfalls, the tidal estuaries, and last, but not least, the waves of the sea, a source which has never been utilized for good. A modern idea is, that it needs nothing but a possible development of art to render these larger sources not only available for power in their immediate neighborhood, but available to supply power wherever it is wanted, and so displace the coal, or replace the power as coal becomes exhausted. The desirability of such a result fully explains the entertainment of the pleasant idea; but, unfortunately, when we come to look closer into the question, the probability of its accomplishment diminishes rapidly. Many of the considerations of which I shall have to speak bear directly on this question; so that I shall now defer its further consideration, merely pointing out that, to accomplish this result, the power must not only be extracted from the water on the spot and at the same time, but it must be transmitted over hundreds or thousands of miles, and must be stored till it is wanted.

It may well be thought that energy in a directed form, or in the army form, may be better transmitted than in the undirected or mob form. As a matter of fact, however, energy has never been and never can be transmitted as mechanical power in large quantities, over more than trifling distances, say, as a limit, twenty or thirty miles. I say never can, because such transmission depends on the strength of material; and unless there is some other material on the earth of which we know nothing, we know the limit of this. This is a part of my subject into which I shall enter more closely in my second and third lectures.

In depreciating the idea that wind and water will ever largely supply the place of coal, I do not for a moment wish it to be thought that I take a gloomy view of the mechanical future of the earth. This, I believe, admits of immense development, and will not for long depend, as it does at present, on the adjacency of coal-fields. This will be explained as I proceed.

CORN AS A SOURCE OF ENERGY.

It must not be forgotten that, after all, the most important source of energy is not coal, but corn and vegetable matter. The power developed in the labor of animals exceeds the power derived from all other sources, including coal, in the ratio of, probably, 20 or 30 to 1; so that, after all, if we could find the means of employing such power for the purposes for which coal is specially employed—such as driving our ships, and working our locomotives—an increase of 10 per cent. in the agricultural yield of the earth would supply the place of all the coal burnt in engines. The energy which may be derived from the oxidation of corn has as yet only been artificially developed in the form of heat, and this may be the only possible way; but physiology has not yet advanced to the point of explaining the physical process of the development of energy consequent on the oxidation of the blood; and it is at all events an open question whether the energy of corn may not be really a form of directed energy, in which case corn would yield six or eight times as much energy as coal does at present, consumed in our engines. As consumed in animals, it yields a larger proportion of energy—two or three times as much, and may be more—whereas, by burning it in steam-engines, we cannot get half as much. Should we find an artificial means of developing anything like the full directable power of corn—a problem which has not yet been attempted—coal would no longer be necessary for power. I do not mention this as a prediction, but as showing that there are, besides wind and water, other, and as yet untried, directions from which mechanical energy may be derived in the future.

Electricity is not a natural source of energy, for the simple reason that the metals have mostly been burnt or oxidized during the past history of the earth. But still it is important, at this stage of my lecture, to point out that the energy consequent on the separate existence of metals and oxygen can be developed without combustion, in a totally directed form, *i. e.*, totally available for power.

There are many peculiarities which distinguish the group of elementary substances we call metals, but there is no more distinctive feature than this. This is not a primary source of power, but, as it at present appears, it promises to become the most important secondary source. We cannot find metals existing in a separate form but by the use of power; where and when it exists, we can separate them from the salts, and so store the energy in a form completely available for power. The economical questions relating to such storage of energy will be considered in their place later in the course.

TRANSMISSION OF ENERGY.

It is not, however, only as effecting storage of power that electricity demands our attention, it also affords a means of transmitting power which has long held an important place in art, and to which all eyes have been recently turned in expectation of something new and startling.

Before considering the developments of art, and the circumstances on which their further development depend, I shall turn, for a moment, to the processes of nature. The mechanics of the universe, no less than those relating to human art, depend on the transmission of energy. In nature, energy is transmitted in all its forms and under all circumstances, both those which we can imitate in art, and those we cannot.

The most important point with regard to the artificial transmission of energy is the proportion of power spent in effecting the transmission, and the circumstances on which this proportionate loss depends. Is such loss universal? So far as we know, it is attendant in a greater or less degree on all artificial means of transmission, and on all transmissions effected by nature on the surface of the earth. If it were not, this earth would be no place to live upon. No motion would ever cease. As it is, the winds and waters are rapidly brought to rest by the friction which they encounter. Currents of wind and currents of water form the principal means by which energy is transmitted over the surface of the earth. But there are other means which experience less resistance. Oscillatory waves, those of sound, are a very efficient means of transmitting energy. Sounds are not transmitted to an unlimited distance, chiefly because, by the spreading of the wave, the sound becomes weaker and weaker as it proceeds. It is also destroyed by the friction of the solid surface of the earth. Hence the sounds which reach us from bodies high up, as the explosion of a meteor, are heard much further than such sounds made at the surface of the earth, although there are two records of artillery having been heard two hundred miles. Owing to such incidental destruction of sound we cannot say from experience that sound waves in foul air are destroyed, but from the physical properties of gases we know they are.

Waves on the sea are another very efficient means of transmitting power, a means which may be called nature's mill. The waves which take up the energy or power from the wind in mid ocean travel onward, carrying this energy, and experience such slight resistance that they will, after traveling hundreds or thousands of miles, destroy the shores on which they expend the last of their energy. If we could find a means of utilizing the energy of waves, we should not only save our coal, but also save our country from the waves; still, water waves experience resistance, which we can better estimate theoretically than practically.

These are the principal ways in which energy is transmitted from one part of the earth to another. There are others, such as earthquakes, but they all show the same thing, that power is spent in the transmission of energy.

If we look away into interstellar space, the case is altered. Here we see two ways in which energy is transmitted—heat, or light, and the motion of the heavenly bodies. In neither of these can we see any direct evidence of resistance or loss of power; and, as judged by any terrestrial measure, there certainly is none. The distance at which we see stars is a sufficient proof of the freedom with which the wave of light travels; while the regularity of the motion of the planetary bodies shows that they encounter no sensible resistance. Yet, although not directly perceivable, there are circumstances that strongly suggest that in both these forms transmission of energy is resisted.

If space is unlimited, and there are stars throughout it, why do not we see them at greater distances than we do? Under these circumstances, there could be no spot in the heavens at which at a sufficiently great distance there was not a star, so that, if the light were not stopped, the whole heavens would be one fiery envelope as bright as the sun. This is a question which philosophers have not decided. But one, and the favorite, way out of the difficulty, is to suppose that the light does encounter resistance, even in interstellar space. This is a subject on which your Chairman of Council has boldly launched; and whether his hypothesis be right or wrong, it has brought to the front a very interesting subject.

With regard to the resistance encountered by the planetary bodies, our evidence is even slighter. A few domesticated comets seem to diminish their speed; and it is not so long since we were all on the *qui vive*, by the promise of the spectacle of an old friend, who seemed to have come earlier than he was expected, on purpose to verify a prediction of plunging into the sun; but instead of doing so he passed away and was pronounced a stranger, to the joy of the nervous, but somewhat to the discomfiture of astronomers.

SUNSHINE ENERGY.

The energy which we derive from the sun comes to us in the form of sunshine, in a highly directed but extremely scattered form, being uniformly distributed all over the illuminated disk of the earth. It reaches the outer atmosphere nearly in the same condition as it left the sun, having traversed ninety odd millions of miles without any sensible expenditure of power. In the twenty or thirty miles of the lower atmosphere, however, it encounters very great, but variable, resistance. Sometimes half of it, or three-quarters of it, may reach the earth's surface. This is rare in our country, and on the average not more than a very small fraction ever reaches the surface.

When the sun does shine, the sunshine is a form of energy which may be, and is, very largely directed so as to yield power. Any such direction which may be accomplished by human art is undertaken at an enormous disadvantage, on account of the scattered manner in which the energy reaches us. The sunshine must be collected before we can make any mechanical use of it.

In the abstract, there are two methods. The one would be to accumulate the energy of sunshine on a given place, over a long time. This is nature's method. The energy on each portion of the earth's surface, during days, weeks, the whole year, or many years, is accumulated by the growth of vegetables. Corresponding to this, however, art has as yet developed no means whatever. If we don't use the sunshine as it falls, energy is lost for all mechanical purposes. I say if we don't, not that we do use it, but because we can, and have done so in a small way. By means of a lens, or reflectors, the sunshine which falls on a certain place may be concentrated on to a smaller space, and so be sufficient to perform some mechanical operation. In this way, small

* Lectures recently delivered before the Society of Arts, London.

vapor engines have been worked by sunshine. But the cost of the apparatus necessary for such concentration is out of all proportion to the result accomplished, and shows the art difficulties must be got over by a new departure. There is the further consideration that sunshine on land is too valuable for the maintenance of vital energy to allow of its being devoted to mechanical purposes.

As regards the perfectness of nature's method, so far as I know, no attempts have even been made to test this. It is probably very wasteful, as are all nature's methods, but it is effective. In the first instance, the energy of sunshine is stored on the spot where it falls, in the tissues, but chiefly in the sap of the grass and vegetation. If this is not removed a large portion of the energy of the year's growth, that which is in the sap, is stored in the seed, and the rest, although apparently again scattered on the decay of the tissues, is to some extent preserved in the ground, and either forwards the next year's crop or takes the permanent form of peat; and our coal fields are but evidence of the way in which the directible energy of sunshine has been stored under circumstances where there was no immediate purpose for which to apply it. Under present circumstances, however, this energy is almost everywhere too valuable to admit of secular storage.

It is either removed directly by nature's method, the teeth of animals, or allowed to accumulate for a longer period, and then removed by human industry. The further aggregation of this energy involves the transmission of energy in a mechanical sense, and hence involves the expenditure of power. Nature works by means of directly converting this energy into power. The plant accumulates the energy of sunshine, the animal collects and appropriates this energy. This collection is accomplished by the expenditure of power, which means a redistribution of that portion of the energy which is capable of direction. The scheme of nature, therefore, is a cycle. The vegetation accumulates the energy, as far as time is concerned, leaving it in a scattered form, requiring power to collect it; this power is in the grass, and only wants direction; this it receives in the animal, which again expends some of the energy in the operation of collecting. If vegetable energy be supplied to the animal in a collected form, then a large portion of the directed energy is available for mechanical purposes. And in this way we may form a rough estimate of the directed energy to be obtained from sunshine in this country. The common agricultural rule is one horse or bullock to two acres, such a horse pulling 120 lb. at a rate of 3·6 feet per second for eight hours a day. This is a nominal horse.

We thus get something like 3,000,000,000 over and above the energy necessary for the energy spent in eating the corn and moving itself, which we must put down as at least equal in amount. Taking only the available portion, we have the equivalent per acre of nearly three tons of coal burnt in such steam-engines as exist at present. Now the average weight of the vegetable produce from one acre, taking the form of straw and corn, would be about two tons. So that, as far as mechanical power is concerned, coal burnt in our present steam-engines, and corn and straw eaten by horses, yield about the same energy, weight for weight.

The energy which we derive from sunshine is scattered all over the earth, and if it is to be utilized at any spot other than that at which the sunshine falls, it must be transmitted by the expenditure of power.

THE ENERGY REQUIRED IN AGRICULTURAL OPERATIONS.

The energy required for immediate operations of agriculture absorbs a large proportion of the actual energy grown. The surplus is available for purposes of art, and we may say that the primary object of man has been to render this surplus as large as possible. This is accomplished, in the first instance, by applying the residue of energy to so ameliorate the conditions of agriculture as to increase the yield and diminish the labor. In this way the land is leveled, inclosed, and drained; buildings are erected, and finally, but most important of all, roads are made. The effect of roads in increasing the surplus energy is probably greater than any other human accomplishment. The only means of transmitting for purposes of collection or other purpose aggregate energy in the shape of corn, without roads, is on the backs of animals. In this way two or three hundred miles was the absolute limit to the distance an animal could proceed, carrying its own food. On a good road a horse will draw a ton of food at twenty miles a day, which would mean that it would proceed 800 miles before it had exhausted its supply, or whatever surplus energy there might be available on one spot; half this would be available at 400 miles distance. The labor of maintaining the roads should, of course, be deducted, but this is very small.

The labor of constructing canals is very great, but the result is equal; a horse can move 800 tons twenty miles a day, or a horse could draw its own food for 80,000 miles on a canal. That is to say, with a canal properly formed, a horse could go five times round the world without consuming more energy than was in the boat behind it. Or corn could be sent round the world with a consumption of one-fifth. On railways, at low speeds, the force required is about ten times greater than on a canal, so that the expenditure in going round the world would be about equal to the total energy drawn. If for a moment we replace the horse by the steam-engine, and the corn by coal, we have to add the weight of the engine to the coal and diminish the efficiency by one-third; we so get that the consumption of coal for the same load of coal as of corn would be about double, or an engine would go about one-fourth round the world, consuming in coal the net weight in the train, that is, exclusive of carriages and engine. Or for every thousand miles corn is carried by rail, something like 10 per cent. of the energy of the corn is expended in draught. This is exclusive of the expenditure in wear and repairs, which will be certainly equal, if not greater. Taking, then, the mean distance by rail between London and the West of America as 2,000 miles, the present expenditure in the energy of corn in transit is somewhere about 10 per cent. The expenditure of energy on the ocean varies, but if transported by steam it would be probably 10 per cent. more, so that at the present time we are actually receiving available mechanical energy, transported in the form of corn, over 2,000 miles of land and 3,000 miles of sea, entirely by artificially directed power, with an expenditure of less than 50 per cent.; a proportion which 200 years ago would have had to have been spent in transmitting it fifty miles over land; a result which has been accomplished by the employment in the mean time of the residual energy over and above that necessary for agriculture, together with a further supply drawn from our coal beds.

Turning now our consideration to coal, we find per weight as used at present, this yields rather less power than corn, but not less than two-thirds, and it then appears that coal may be transmitted at the present time, between any two places on the earth which are connected by rail and water, with an expenditure of less than 50 per cent.

In instituting this comparison, the standard has been the actual available power, as developed in our present engines and in horses, with which, weight for weight, there is not much difference. But the adaptability of this energy, so developed for particular purposes, renders the one medium much more valuable than the other. Thus for agricultural purposes, weight for weight, horse food is worth in money ten times as much as coal. This shows the extreme difference in the value of energy according to its adaptability; and the extension, for which there is unlimited scope of the adaptability of steam power, may render it ten times as valuable as at present; nor would this be any small proportion compared with the total energy employed in the work of the world. In this country there are said to be between two and three million horses, and we may put the laboring men down at five millions, or as the total power derived from corn down as over three million horses. From the best information going, the work done by steam in this country does not exceed the labor of two million horses, so that more than half the energy is still derived from corn. A greater proportion of the actual corn used for horse food comes across the Atlantic; and for many years maize was sold in this country at an average price of £6 or £7 a ton, the cost of transit being a very small matter. Of course the same cost, say £1 per ton, applied to coal would be a serious matter, considering the low price of the latter. But if, in the present state of our art, energy can be transmitted by corn from any part of the world to this country with an insensible rise, there is no reason to suppose but that, with the advance which science shows us, there is every reason to expect coal may be transmitted with a corresponding small increase in its cost, wherever the demand for it is sufficient to recompense the outlay necessary for opening the roads or canals.

II.

In my last lecture I dealt with the transmission of energy through the means of coal and corn, showing that by either of these means power may be transmitted by rail with an expenditure of $\frac{1}{15000}$ per mile, or by water of $\frac{1}{150000}$ per mile, this either through the agency of horse or steam.

This ease of transmission, however, depends entirely on the railroad or water, and is only possible between places so connected. Hence such means are only applicable to what may be called the mains of power.

We come to-day to consider other means of transmitting energy in smaller quantities applicable to its distribution for immediate application. Such transmission is not a matter of secondary importance, although the distances over which it is transmitted may be comparatively insignificant. To emphasize this, I may recall what was previously mentioned, namely, that the relative price of corn and coal shows that the power given out by horses is at least ten times as valuable as that of steam, for more than half the purposes for which energy is used; or that it answers better to burn our coal in bringing corn from America to plow in England, than to use the coal here for plowing.

In fact, for most of the detailed purposes for which power is used, to draw it from a large source (such as a steam-engine), distribute it, and adapt it to its purpose is ten or twenty times more costly than its transportation in large quantities over thousands of miles.

Now the means of artificially transmitting power may be considered as three. The power may be stored in matter in various ways, and the matter with the energy transported—as, for instance, in our watch springs. The second means is the transmission of power by moving matter without actually storing the power in the matter—as in shafts and belts, hydraulic connection, etc. And the third method, which is distinct from the others, is the transmission of energy, in the form of heat or electricity, by the flow of currents through conductors; in this way all the power in the steam passes through the boiler-plates from the furnace into the boiler. Of course, each one of these means includes an infinite variety of detailed contrivances, more or less dissimilar. But there is good reason for classing them under these three heads, for all the contrivances under each of these heads are subject to the same general limits whether those of efficiency or distance.

There is one thing in common to all these means of transmission, and that is that they all involve a material medium. The quantity of matter required constitutes a primary consideration in all of them. This quantity of matter is fixed by what we may call the properties of matter, one of the most important of which, as regards the first two means, is the possible strength of material. Looking round, we see the effect of the limited strength of material in all nature's works. Of course it may be that we shall be able to work with stronger materials than we have at present. Organic materials, such as the feathers and tissues of animals, are stronger than steel, weight for weight, so that there is a possibility of improvement, but that man will go beyond nature in constructing organic fiber seems improbable, and such possibility of improvement as exist may be discounted. At present we may set down our strongest working material as steel, the art of working in which is so perfect that we may calculate on nearly the greatest strength for all purposes. I have taken fifteen tons on the square inch as the limit of safe working tension, in making the estimates which I shall now bring before you. First of all, I will ask your attention to the possibilities of transporting power in a stored form.

STORED ENERGY.

The question of economy in the conveyance of energy in a stored form is simply one of the intensity with which it can be stored. If we want to carry energy about, we must have it stored in some material form—and this material has to be carried by ordinary means—so that the question of economy is simply the amount of available energy that we can store in a given amount of material.

If energy, stored in a particular manner, is more readily available for some special purpose than that stored in another, then it may, on the whole, be more economical to carry it in that form. This is abundantly illustrated in our watch springs.

SPRING POWER.

The greatest amount of energy that can be stored in a given weight of steel is very small, compared with other means. To take a familiar unit, to store the energy necessary to maintain one horse-power for one hour would require no less than fifty tons of steel—that is to say, fifty tons of steel in the form of watch springs, all fresh wound up, would not supply one horse-power for one hour; and yet this is the commonest form in which energy is carried about.

It is the adaptability of the spring, and the readiness with which energy can be put in and taken out, which recommend the steel spring.

India-rubber will store much more energy than the same weight of any other material, say eight or ten times as much as steel; but with this several tons would be required to store the horse-power for one hour.

ENERGY OF COMPRESSED AIR.

A much more capacious reservoir, according to its weight, is compressed air. There are certain difficulties in getting the energy in and out without loss; but with air, compressed to four times the pressure of the atmosphere, we should only require about 20 lb. of air to yield the amount of one horse-power for one hour. Of course, if we were going to carry this air about, to the weight of the air would be added the weight of a case to contain it, and such a case, in the form of steel tubes, would weigh something like 280 lb.; so that in any form in which we can carry compressed air about, we shall have about 300 lb. to carry for each horse-power per hour.

HOT WATER ENERGY.

Another means of storing energy, very largely used, is hot water. This is largely used in a way not always recognized. The boiler serves another purpose besides that of converting the energy of the furnace into the power of the steam. It stores the power, and equalizes the stream between the fire and the engine, a function the importance of which has been brought to the front in the recent efforts to apply electricity for communication of power, where the want of a similar reservoir between the generator and the motor has, in many cases, proved fatal to the enterprise, a want which secondary batteries are now being used to meet.

Hot water has also been employed as an independent reservoir, and as such it is better in some respects than compressed air. The fundamental limits are of much the same kind. In this case, however, the absolute limit is temperature. The vessel in which the water is carried must be strong enough to withstand the pressure, and all materials lose their strength as they get hot. The considerations are here much the same as in the steam-engine, and 400° Fahr. appears about the limit. At this temperature, for every 4 lb of water the cases would weigh 1 lb., and there would be no advantage of large over small cases; except as a matter of construction, the proportionate weight would be the same. The gross power of a pound of water, the steam being used without condensation, is about 20,000 foot-pounds, or we should require 50 lb. to store 1,000,000; this is the extreme limit again. The present accomplishment would be about 150 lb. per 1,000,000 foot-pounds stored—rather less than compressed air. The only other means of packing power, that is at present looked to, is that of the much talked about secondary battery. Here there is a great deal of doubt as to what is actually accomplished; take the most reliable statements from which it seems that in order to get 1,000,000 something like 100 lb. of battery is required, which will make this means of storing energy very much the same as compressed air or hot water.

COSTS OF DIFFERENT FORMS OF ENERGY.

It is important to notice that the initial cost of the energy stored by these means differs considerably. This cost is rather difficult to estimate; but a practical estimate may be formed in this way:

Taking the power, as delivered by the steam-engine, as 1, how much of this power will be given out after secondary storage? Here the hot water has an advantage, for it is heated directly by the coal, and is all on its way to the steam-engine.

With compressed air, there are three operations, each as costly as the steam-engine, and at least half the initial power is spent during the compression, storage, and expansion; so that the energy is at least double as costly in coal, and six times as costly in machinery. I have put it down as three times as costly as the energy in hot water, but this is considerably below the mark. The electricity has also to go through three operations, and cannot be less costly than compressed air.

Now, if we revert for one moment to the consideration of the main transmission of power, we see at what an immense disadvantage any form of packed energy is, compared with coal or corn; as at present packed it weighs at least one hundred times as much.

While the limits imposed by the strength of material render it certain, as far as compressed air and hot water are concerned, that the weight can never be reduced by more than half, these limits are sufficient to show that packed energy cannot be transported over long distances, even if it can be obtained directly from such falls as Niagara. But this is no argument against the importance of these means for short distances and special purposes. As I have already pointed out, our watches show that circumstances may render the very heaviest means the best for particular purposes. And if in any of its forms packed energy were directly available for household purposes, though it cost ten or twenty times as much as power direct from the steam-engine, its use would still be assured.

One fact should be noticed, that in all these forms the power is packed, and needs nothing but drawing off, whereas corn or coal do not contain the power. The oxygen is an equally essential ingredient. In this fact lies the great advantage of corn and coal for transportation. They are really, so to speak, but checks for power, which can be cashed at any spot where a bank, in the form of a steam-engine or a horse, exists. But, of course, not being energy, they are not generally current—in fact they are worthless, except where the bank exists, and where they represent such small amounts that the banks refuse them. Now these forms of packed power are, so to speak, generally current; that is to say, they are available under almost all circumstances, and in greater or less degrees of smallness; from the very smallest, which is the watch spring in our pockets, which supplies a continuous stream of power in less than one ten thousand millionth of a horse-power; or the Whitehead torpedo, which carries some million foot-pounds of energy under the sea.

LOCOMOTIVE FORMS OF ENERGY.

Perhaps the most pressing purpose for which these forms of packed energy are wanting is that of locomotion.

The distance which a locomotive body, be it animal or machine, can travel, loaded or free, is limited by the ratio or the power which it carries to its gross weight. The speed which it can attain is limited by the rate at which it can use its energy compared with its weight. Hence there are two particulars in which we can compare the different forms of stored energy for locomotive purposes.

Let us take the horse and the locomotive. A full-sized horse weighs, say, 1,500 lb., and, at a rate of 2½ miles an

hour, will go five hours without food, doing about 10,000,000 foot-pounds of work, including the work necessary to move itself; this represents the largest result, or about 150 lb. per 1,000,000 foot-pounds. If the horse is put to ten miles an hour, it will not do more than 125 foot-pounds in a single journey, besides moving itself. Probably the greatest rate at which a horse can use its energy is about 4,000,000 foot-pounds per hour, or 750 lb. per horse-power.

A locomotive with its tender, say, weighing sixty tons, exerts 500 horse-power gross—270 lb. per horse-power per hour; so that a first-class locomotive with tender is above one-fifth as heavy for its power as the horse; but then the horse cannot go more than ten miles an hour.

Now, in a general way, passenger-locomotives carry coal and water for eighty or one hundred miles, *i. e.*, two hours; or the locomotive already mentioned expends at one run about 2,000,000,000 foot-pounds; which means that the gross weight of the locomotive is about 76 lb. or 70 lb. per 1,000,000 foot-pounds of power with which the locomotive starts.

In thus taking the gross weight of the horse or locomotive, we must remember that this includes the weight of carriage and machinery, and that in whatever form the energy is carried, this weight must be added. In the locomotive the weight of water and coal in the tender for two hours' journey weighs about one-quarter the gross load; and if we add the weight of the boiler, we may consider the carriage and machinery at one-half to one-third the gross load. Taking the latter, and substituting for the boiler, coal, and water, energy in either of the above forms, the coal, water, and boiler would be about 40 lb. per 1,000,000; so that, if we took compressed air instead, we should have one-fourth the power; or the engine would run for thirty minutes instead of two hours, a distance of twenty-five miles instead of a hundred. A fireless locomotive might do more than this, say, thirty-five minutes, or thirty miles at the same speed as the locomotive. Faure's battery, if it could be made to work at all, would carry the locomotive forty-eight minutes, or thirty-five to forty miles.

These figures seem to show that the locomotive has little to fear from any of these rivals, that is, under circumstances where the smoke and steam are no harm, and where a full-sized locomotive is required. But there are already some cases where the locomotive is required and where the burning of coal is impossible. Should the Channel Tunnel be made, there will be a great field for some form of packed energy; but it does not seem that the promoters have much faith in a smokeless means of working the tunnel being forthcoming. As regards horses, however, there is nothing to show why the horse should not be rivaled by some one of the forms of packed energy. There have been inventors who have constructed carriages to go by clockwork. This has now become possible, substituting hot water, compressed air, or a battery for the spring, and such means have already rivaled the horse on tramways. The fact that horses are at all used for tramcars is a matter of as much surprise as that steam should be used on underground railways. For locomotives driven by compressed air might certainly be made cheaper and better in every way.

At the present time it would probably answer well, in a pecuniary point of view, to supply in compressed air energy at the rate of 2d. or 3d. per 1,000,000 foot-pounds, provided a sufficient quantity could be required; so that if simple and efficient means of applying such energy to perform the heavier part of manual labor, we might get as much power for 6d. as what a man will do in a day at 2s. But it is the means of applying it that is wanting.

Even for horse work—except where there is a railway or tramway—the mechanical means are wanting. We have no mechanical substitute for the horse's foot. So that although there are more than a million horses in this country continually engaged in the operations of husbandry, where they work in groups so as to get three or four horse-power at one operation, an amount of power not too small for the direct application of steam power; and although for twenty-five years steam-engine makers have been doing their very best to adapt the power of the steam-engine to this labor, which exceeds any other actual application of power, the possibility of steam plowing with economy is still a question. The use of steam on paved or on macadam roads is much the same, so that, until steam has been applied to such purposes, there is little hope for other forms of stored energy.

POSSIBILITIES OF THE ELECTRICAL STORAGE BATTERY.

Coming back for a moment to Faure's battery, I would carefully point out that the result which I have put down—100 lb. per 1,000,000 foot-pounds of energy—refers to what has been already accomplished, and not to any possible limit. The principles involved in the chemical action of these batteries, in fact in all batteries, are well understood; and so far as these principles are involved, it is easy to define limits; but there are a number of secondary actions which are not so well understood, and which have hitherto prevented any approach to the theoretical limits. In the Faure's battery, the theoretical limits are about 3 lb. per 1,000,000 foot-pounds. That is to say, the oxidation of 1 lb. of lead to litharge, and the deoxidation of 1 lb. of peroxide, together, yield 360,000 foot-pounds. How far, at present, Faure's battery is within this limit, at once appears something like twenty-four times. Should this be accomplished, power could be packed at the rate of 1,000,000 foot-pounds for 3 lb., or say 6 lb. weight, to allow for wastes, a result which would most certainly displace steam in the locomotive, but which would still leave coal and corn six times the lightest vehicle of power.

It should be noticed, however, that although the means of doing so are still entirely wanting, could other metals, such as iron or zinc, be used instead of lead, the results would be much greater. This is shown by the relative amount of power necessary to oxidize or deoxidize these materials, which we see for iron and zinc are five or six times greater than for lead; here is an apparent opportunity for art.

Should this be realized, then, indeed, coal might be displaced as the cheapest medium for the transmission of power, but that would be a small matter compared with the change that would occur in our ways of applying power. For the dream of Jules Verne, of 20,000 miles under the sea, would become a reality, and, instead of steamboats, we should travel in submarine monsters as yet unnamed, which we may call steam fish.

But if science as yet imposes no limits beyond those I have mentioned, at the same time it holds out no prospect. The chemistry of these batteries has been very deeply considered, and those who have studied the subject most deeply apparently see no direction in which to direct their efforts; so that any great advance in this art must entail a great discovery in science.

There now only remains for me to consider the transmission of power as power, or by electricity, a most important branch of my subject, which I must take in my next lecture.

III.

THE TRANSMISSION OF ENERGY.

So far I have spoken only of the conveyance of power by means of coal, corn, or in one or other of the several forms of packed energy. To-night I come to consider the transmission of power by what are more distinctly mechanical methods, and by currents along pipes and conductors. These are the means by which power is almost always distributed, *i. e.*, transmitted from the acting agent, be it horse, water-wheel, or steam-engine, to its operation, whatever it may be. In most cases the distance of such transmission is so short as to be the subject of small consideration in determining the means to be employed. That is to say, the means are chosen rather by their adaptability to receive and render up the power than by the efficiency with which they transmit it. Thus, if we take an ordinary mill, the shaft which receives the power is generally driven at that speed which is best adapted to receive the power from the engine, and deliver it to the machinery in the mill, without considering whether a much smaller shaft might be used if it were caused to run at a much higher speed. Thus, in a mill driven by an engine of two or three hundred horse-power, the shaft which receives the power will generally be five or six inches in diameter whereas it would be possible to use a shaft of two inches in diameter if the efficiency of the shaft were the only consideration. Or, again, take a screw steamboat. The distance from the engines to the screw may be 250 feet, the power 10,000 horse. This could be transmitted by a shaft twelve inches in diameter, if allowed sufficient speed, but the screw has to make sixty revolutions per minute, and this determines the speed at which the shaft is made to run, and hence the shaft is made thirty inches instead of twelve inches. This is because, owing to the smallness of the distance, the efficiency of the means of transmitting the power is a small consideration. There are, however, many circumstances under which it is impossible to bring the source of power close to its work, and then either mechanical power is not used, or the efficiency of the means becomes a consideration.

In other cases it is a question whether it is better to distribute the sources of power, such as steam-engines, so that they may be near their work, or to use one large source, and distribute the power by some mechanical means. This rivalry exists in almost all engineering work which covers a large area, and, generally, a compromise is come to, engines being distributed about the works, and the power of these distributed to the machines by means of shafting. In many cases separate engines are used for each machine, but not often separate boilers, the power being distributed by steam-pipes.

Dockyards have long afforded a field for the competition of the various means of distributing power. Here, generally, the distances between the operating machines, such as cranes and capstans, is considerable, and the work required from each machine very casual. And every means of distribution is or has been in use, from a separate engine and boiler to each machine, as at Glasgow (separate engines drawing their steam from central boilers), to a complete system of hydraulic transmission from a central pumping station, as at Grimsby or Birkenhead.

But the question between centralization or distribution of steam-engines is not by any means the only one, or most important one, which depends on mechanical means of distributing power. Every improvement in the means of distributing power from a central engine opens a fresh field for its use.

The considerations relating to this subject are numerous. Hitherto, as regards the main transmission of power, the principal consideration has been the percentage of loss according to the distance; but, as regards the final distribution of power, the form in which it is distributed must be such as admits of its being at once available for its purpose. Thus hydraulic distribution is favored in dockyards, because it is required for heavy forces and slow motions, but where rapid motion is required, hydraulic distribution gives place to some other.

Again, where the quantity of power that has to be distributed is a most important consideration, the distribution by means of water or compressed air will generally be the most efficient, whereas these would be by far the most costly means for small quantities. It thus has to be remembered that, besides the general question of efficiency, each means has particular recommendations for particular purposes.

It is not, however, with these particular recommendations that I am concerned. My object is to show the limits within which the use of each means is confined, however fit it may be for its purpose. Taking first the mechanical means, which are shafts and ropes, we find that the possible limits to both these means are absolutely defined by the strength of material. The amount of power any piece of material will transmit by motion against resistance, is simply the mean product of the stress or force acting in the direction of motion on the section multiplied by the velocity, so that, if the stress is uniform over the section, the work is the product of the area and intensity of stress and the velocity.

TRANSMITTING POWER BY SHAFTS.

In a revolving shaft, neither the stress nor velocity are uniform over the section, both varying uniformly from nothing in the middle to their greatest value on the outside; so that their mean product is exactly half the product of the greatest values. The greatest power per square unit of section a shaft can transmit is half the product of the greatest stress into the velocity at the outside of the shaft.

Taking, then, the greatest safe working stress for steel at 15,000 lb. on the square inch taking what is the greatest practical velocity at the surface, 10 feet per second (the speed of railway journals); the work transmitted is 75,000 foot-pounds per second per square inch of section—135 horse-power; so that we should have to have a shaft of upward of 7 square inches in section to transmit 1,000 horse-power, that is, a shaft of over 3 inches diameter. The friction between such a shaft and lubricated bearings is well known, 0·04; so that, calculating the weight of the shaft 24 lb. per foot, we have power spent in friction about 52,000 foot-pounds per mile, that is, one-tenth the total power the shaft will transmit. That is, if we put 1,000 horse-power into a 3-inch shaft, making 500 revolutions per minute, we ought, at the end of a mile, to be able to take 900 horse-power out of it. If we had to go farther, the size of the shaft might be diminished, so that in the next mile we should again lose a tenth, and if we repeat this process seven times, we shall, at the end of seven miles, have left about half the original power put in.

It will be thought, perhaps, that a 3-inch shaft is very small to transmit so large a force; this is because the speed of 500 revolutions per minute is inconveniently high for purposes of employing the power; but if it were merely a question of transmission, it would be about the best speed. This, then, shows the limit of the capacity of shafts as transmitters of work.

TRANSMISSION OF POWER BY ROPES.

Turning now to steel ropes, these have a great advantage over shafts, for the stress on the section will be uniform, the velocity will be uniform, and may be at least ten to fifteen times as great as with shafts—say 100 feet per second; the rope is carried on friction pulleys, which may be at distances of five or six hundred feet, so that the coefficient of friction will not be more than 0·015, instead of 0·04. Taking all this into account, and turning to actual results, the work transmitted per inch would be 1,500,000 foot-pounds per second; or that a ¾-inch rope is all that is necessary to transmit 1,000 horse-power in one direction; this would make the loss per mile only 1-60. But in practice, the rope has to be worked backward and forward, and the tension in the backward portion of the rope must be half the tension in the forward portion. This reduces the performance from 1-60 to 1-20, which would cause half the work to be lost within ten miles. If we use a bigger rope, and run at lower speed, then the coefficient of friction would be reduced to 0·1, and the distance extended to fifteen miles.

Experience with ropes is large, and they have been found, without question, to have been the most efficient mechanical means of transmitting power to long distances, but their use is subject to drawbacks. The ropes wear somewhat rapidly, as do also the pulleys on which they run, and this circumstance is very much against their use in any permanent work. Nevertheless, they are used for working mines, steep inclines, and steam plows; while at Schaffhausen they have been used for transmitting power to considerable distances.

TRANSMISSION OF POWER THROUGH PIPES.

Turning to the transmission of power along pipes, we find the conditions somewhat modified. The formula for the amount of power transmitted by water is the same, namely, the product of the area of section into the velocity. But the resistance obeys different laws. In the case of shafts and ropes, we have seen that the distance is subject to an absolute limit.

In the case of fluid in pipes this is not so. No matter how long a pipe may be, if there is no leakage, water would flow along the pipe until the level of its surface were the same at both ends. But the rate of flow would diminish with the length and diameter of the pipe. Thus we can transmit power through a perfectly tight pipe, however small, and however long; but when we come to consider the gross power that can be transmitted through a given pipe, with a given percentage of loss, the question is different. Given the size and strength of the pipe, the gross amount of power, and the percentage of loss, and the limits are fixed. Thus, taking a 12-inch pipe capable of standing 1,400 lb. on the square inch, the loss in transmitting 1,000 horse-power would be about 5 per cent. per mile, at first increasing—as the pressure fell to 700 lb.—to 10 per cent. We should thus have lost half the power in about seven miles. We cannot say that seven miles is the absolute limit, for with a 24-inch pipe, which would cost four times as much per mile, we could transmit the same power thirty times as far with the same loss. The cost of laying a 12-inch pipe for seven miles, however, would probably be as much as even 1,000 horse-power would stand; while a 24-inch pipe for 200 miles would be out of all proportion. Then there is the consideration of leakage, which, although very small for short lengths, is larger for greater lengths.

Seven miles is at present an outside economical limit of hydraulic transmission, even for such a large amount of power; but with air the case is different. This flows so much easier than water, that the cost of transmitting the same power through the same distance, with the same loss, would be about 12 per cent., or, at the same cost per mile, the air may be transmitted 100 times as far with the same loss. The total cost, however, would thus be 100 times as great, which would exceed the economical limit; but not only theory but practice has shown that power may be economically transmitted five times as far by air as by water—something like thirty miles. But on comparing these two means, one circumstance must not be lost sight of, and that is, that getting the power into the pipe in the form of compressed air will cost twice as much as getting it in the form of water. This is a great advantage for water where the distance is short, but where the distance is long, the greater efficiency of air more than compensates for this initial loss.

Like water, air can only be transmitted economically where the quantity is large, the friction being proportionately greater in small pipes than in large, varying as the four-fifths power of the diameter.

This is a great drawback, both as regards hydraulic and compressed air transmission. It does not affect ropes and shafts in the same way, but even in these cases considerations of durability prevent these means being used efficiently for the transmission of small quantities of power to considerable distances, so that, with the possibility already mentioned, there remains an opening for any means that will enable power to be transmitted efficiently in small quantities, and such a means we have in the flow of electricity along wires or conductors.

TRANSMISSION OF POWER BY ELECTRICITY.

In considering electricity, we may well start with the questions—1. Will electricity enable us to transmit power in large quantities more efficiently than the foregoing means? 2. Will it enable us to transmit small quantities? These questions may be more definitely answered than they could a few weeks ago. Thanks to the experiments of M. Deprez, who appears to have been the only one, out of all those who are advocating the use of electricity, who has had the courage to try and see what can be done, we can now say with certainty that a current of electricity, equivalent to 5 horse-power, may be sent along a telegraph wire 1·6 of an inch in diameter, some ten miles long (there and back) with an expenditure of 29 per cent. of the power, because this has already been done. In order to do this, it would seem that M. Deprez has perfected his apparatus so as to have nearly reached the possible limit. Compared with wire rope, this means falls short in actual efficiency, as Messrs. Hems send 500 horse-power along a ¾-inch rope. To carry this amount, as in the experiment of Deprez, one hundred telegraph wires would be required; these wound into a rope would make it more than 1·4 inches in diameter, four times the weight of Mr. Hems' rope. With the moving rope the loss per mile is only 1·4 per cent., while with the electricity it was nearly 6; so that, as regards weight of

conductor and efficiency, the electric transmission is far inferior to the flying rope. Nor is this all. With the flying belt, Mr. Hems found the loss at the ends, in getting the power into and out of the rope, 2½ per cent.; whereas, in M. Deprez's experiment, 30 per cent. was lost in the electric machinery alone, which is very small as such machinery goes. But this is not all. No account is here taken of the loss of power in the transmission to and from the electric machinery, a matter which is, I believe, very much underestimated.

The machines made revolutions at 1,000 and 700, much too high for direct connection with either a steam-engine or any mechanical operator; the power, then, had at each end to be transmitted through gearing, or a system of belts. And supposing this alteration of speed to have been five or six at each end, experience tells us that a loss of at least 15 per cent. must ensue. This loss was indeed apparent, for the dynamometer was connected with the machine with a belt, which showed a loss from this one belt alone of 20 per cent. Taking the whole result, it does not appear that more than 15 or 20 per cent. of the work done by the steam-engine could have been applied to any mechanical operation at the other end of the line, as against 90 per cent. which might have been realized with wire rope transmission. To set off against this, electricity has the enormous advantage in the conductor being fixed, and in the fact that it is likely to be, if anything, less costly and more efficient for small quantities of power than for large. These advantages will certainly insure a very large use for electricity in the distribution of power, particularly for high speed machinery.

TRANSMISSION OF ENERGY BY GAS.

There is yet another means of communicating and distributing energy now coming rapidly into vogue. This is by the transmission of coal gas along pipes. The distances, often many miles, through which the gas is often transmitted before reaching the engine, are such that, with any other means of distributing power, would considerably enhance the cost of the power. But in the case of gas, it does not appear that these distances are at all a matter of consideration. This may be at once explained. It takes about ten cubic feet of gas to develop 1,000,000 foot-pounds in a gas-engine, whereas of air compressed in the ordinary way it would require something like 140 cubic feet to yield the same power. Hence the comparative cost of transmission is the cost of transmitting ten cubic feet of gas against that of 140 cubic feet of compressed air, and these would be about as one to twenty-five; so, as a means of distributing energy, gas is twenty-five times more efficient than compressed air.

I have now placed before you, as far as circumstances will allow, the various means by which energy, in a form available for power, may be transmitted over long distances, together with the circumstances which limit such transmission. By means of the railway and steamboat, corn and coal can be, nay is, transmitted half way round the earth with an expenditure of power of less than half the power represented by the coal carried, but this can only be done where the quantity to be transmitted is very large.

At present the efficiency is unrivaled, no means of packed energy or of current energy approaching even 1 per cent. And further, there is apparent room for a large diminution in the present expenditure, small as it is, in the improvement on the steam-engine as a means of directing the energy of coal. For the distribution of power, this means ceases to be efficient, nor can it be employed to transmit energy which has already taken the form of power. For these purposes other means have to be employed. These various means, although they differ greatly in efficiency, all fall so far below the efficiency of coal and corn, that a hundred miles appears to be the outside limit any economical transmission of power, in quantity for mechanical purposes, could be at present effected; and hence any power, be it derived from wind or water, must be used within this radius of its source; and, except in places far out of the reach of rail or water, this limit may be divided by ten.

So far as efficiency of transmission in considerable quantities, neither secondary batteries nor electrical transmission are more efficient than compressed air or belts, but when it comes to transmitting small quantities, then electric transmission has a decided advantage. The cost of the electric conductor diminishes with the quantity to be transmitted, and by making the conductor sufficiently large, its efficiency may be increased to any extent.

At the present time, electric conductors are continuous half way round the world, and whenever a message is sent from England to Australia direct energy is transmitted 10,000 miles, but in what quantity? The energy of the current, as it arrives, is not much more than sufficient to keep a watch going, at any rate not more than 1-1,000 millionths of horse-power. The value of such energy, estimated at £17 per minute, would be equivalent to a billion pounds per horse-power per hour, whereas the highest price paid for animal labor in Australia or England is not more than 6d. per horse-power per hour. This shows the difference between the transmission of electricity for telegraphic purposes and its transmission for mechanical purposes. Energy differs in value greatly, but for operations that can be performed by men or horses, the price of energy must be regulated by the highest price of corn.

The prosperity of any spot in the past depended on the fertility of the adjacent soil. But the use of coal has altered this, and now the present prosperity of this country is owing to the adjacency of our coal-fields, these having rendered it possible to bring our food across the earth. The improved means of transmitting coal and corn, it would seem, have, or may again, change this, and if, instead of looking on the life of this country as limited by the life of our coal-fields, we look boldly forward, and foster every means, political, social, and mechanical, which may render this a favorite spot to live upon, we need not fear that the necessity of bringing our coal from a distance will make a difference which will counterbalance the advantage we shall derive from the mechanical facilities we shall have here.

EXTERNAL USE OF CASTOR OIL.

THE London *Medical Journal* gives reports from various practitioners who have found purgative results follow the inunction of castor oil. One writer states that he has frequently applied this oil to the abdomen, under spongiopiline or other water-proof material, in cases where the usual way of administering by the mouth seemed undesirable, and with the most satisfactory consequences. In a case of typhoid fever, also, half an ounce of castor oil was applied in this manner, under a hot water fomentation, the effect of this being, as represented, to relieve the constipation and tympanitic distention that had been present, without undue purging or irritation of the bowels.

THE TOMB OF HARVEY.

THE professional event of Oct. 18, 1883—the removal of the remains of William Harvey to their new resting place—has been attended with one most satisfactory result. It has called forth the general sympathy and approbation of scholars of every class. Nothing could be more gratifying than the tone of the leading organs of public opinion on the claims and merits of the immortal discoverer of the circulation of the blood. Each writer has commented on a pure, independent, and blameless life; each has shown how calmly and wisely Harvey underwent the troubles of criticism; how quietly he bore, with modest knowledge of his own greatness, the homage of friends; how confidently he trusted in the future as the sustainer of his originality, his patience, his industry, and his success. William Harvey, in fact, never stood better or brighter before the world than when the eight Fellows of his College bore his remains from the vault at Hempstead Church to the marble tomb in which those remains are now permanently enshrined. It is worthy of notice, also, that those who have written of him so appreciatively have set forth his merits from one side of his work alone. They have, naturally enough, confined their comments mainly to his discovery of the circulation of the blood. Yet, if they had read the large volume of the works of Harvey, the "Opera Omnia," one copy of which was buried with their author, they would have discovered that the work "De Motu Cordis" was but a tithe of the volume, and that the work on Generation was not only much larger, but was really as pregnant of purest and choicest originality as the better known and better understood treatise. We may, therefore, expect that, as time runs on, and the labors of our greatest anatomist become still more widely known among the educated classes of the community, the fame of the man will shine forth with a still greater luster.

Of the manner in which the great event passed off we have nothing to add except congratulation. Everything was propitious. The day was beautifully fine; the arrangements, which had cost the committee and the subcommittee most serious and anxious labor, worked well up to the last; and, as one of the oldest Fellows aptly expressed it, the day was one of those which happily leaves behind it nothing that any one could have wished to alter. In the course of time many feet from many places of the earth will travel to the church of Hempstead to see the tomb of Harvey. The resting-place of his remains, like that of the remains of Shakespeare, will be one of the national monuments that strangers as well as natives will feel it imperative to visit. Over and over again will be recited to the interested visitor the story of the re-entombment, and how after a lapse of two hundred and twenty-six years the Fellows of the College of Physicians a second time performed funereal rites. Perhaps it will be told, too, that whereas the first company of Fellows was probably some days traveling from London to Hempstead, the second sped there in a pleasant afternoon ride of three hours and returned to the metropolis to sleep. Perhaps in the course of still longer time the protection now rendered to the lead in which the remains were originally "lapt" may in its turn wear away, and an antiquarian committee sit on the "scroll" to decipher the record, and speculate on the specimens of photographic art which accompany it. Perhaps the tomb, like that of Archimedes, may be forgotten until some other Quæstor Cicero rediscovers it, and clears it from its obscurity. But whatever of these things may happen, we may be content, in the present, with what has been done, and for once in a way change a doleful proverb into a happy—"sufficient for the day is the good thereof."—*Lancet.*

THE SIX GATEWAYS OF KNOWLEDGE.

AT the recent distribution of prizes to the students of the Birmingham and Midland Institute, Sir W. Thomson, the president, delivered an address, of which the following is an abstract:

He said, in commencing, that if he were asked to give the subject of his address a title, he might call it "The Six Gateways of Knowledge," that subject being closely connected with the studies for which the prizes had just been presented. The question he was going to ask them to think of was—what were the means by which the human mind acquired a knowledge of external matter? John Bunyan likened the human soul to a citadel on a hill, self-contained, with no means of communication with the outer world except by five gates, viz.: the eye gate, ear gate, mouth gate, nose gate, and feel gate. Bunyan was clearly in want of a word there. He used feeling for the sense of touch, a designation which to this day was sometimes so commonly used that he could scarcely accuse it of being incorrect; at the same time, the more correct designation undoubtedly was the sense of touch. The late Dr. George Wilson, first professor of technology in the University of Edinburgh, wrote, some time before his death, a beautiful little book under the title of "The Five Gateways of Knowledge," in which he quoted John Bunyan in the manner he had indicated. He had said, however, six gateways of knowledge, and he must try to prove that we had six senses. The six senses he intended to explain were the sense of sight, the sense of hearing, the sense of smell, the sense of taste, and the sense of touch. The sense of touch, however, must be divided into two departments. The sense of touch was very distinctly of double quality. If he took up a particular body, he perceived a complication of sensations, a certain sense of roughness, but he also perceived a very distinct sensation which was not of roughness or smoothness. There were two sensations. If he dipped his hand into a bowl of hot or cold water, the moment he touched the water he perceived a very distinct sensation. That was not a sense of roughness. The sensation of the cold water was comparable with the sensation of heat, although it was opposite. Still it was comparable with the sensation of heat. He was not going to say they had two sensations in that department—a sense of heat and a sense of cold; he should endeavor to explain the sense of heat. The perceptions of heat and cold were perceptions of different degrees of one and the same quality, but that the quality was different from the sense of roughness. The sense of roughness was the sense of force, and the six senses which he wished to explain were the sense of sight, the sense of hearing, the sense of taste, the sense of smell, the sense of heat, and the sense of force. The sense of force was the sixth sense, or rather the senses of heat and force were the sense of touch. He had hinted at a possible seventh sense—a magnetic sense. He wished, however, in passing, to remove the idea that he was in any way supporting that wretched, groveling superstition of animal magnetism, spiritualism, mesmerism, or clairvoyance, of which they heard so much. There was no seventh sense of the mystic kind. Clairvoyance and so on was the result of bad observation, chiefly, somewhat mixed up with the effects of willful imposture acting on an innocent and trusting mind. If there was not a distinct magnetic sense, it was a very great wonder that there was not. The study of magnetism was a study of a very recondite subject. One very wonderful discovery that was made in electric magnetism was made by Faraday and worked out very admirably by Foucauld, an excellent French experimenter, showing that a piece of copper or a piece of silver let fall between the folds of a magnetic field would fall down slowly as if through mud. Was it conceivable that if a piece of copper could scarcely move through the air between the poles of an electric magnet, a human being or living creature in the same position would experience no effect? Lord Lindsay got an enormous magnet so large that the head of any person wishing to try the experiment could get well between the poles, and the result of the experiments was marvelous—the marvel being that nothing was perceived. He, however, did not admit, he did not feel, that the investigation was completed. He could not but think that the quality of matter in the air, which produced such a prodigious effect on a piece of metal, could be absolutely without any—it was certainly not without any—effect, but that it could be absolutely without any perceptible effect whatever on a living body. He thought the experiment was worth repeating, worth examining, whether or not an exceedingly powerful magnetic force was without perceptible effect on a living vegetable or animal body. He thought, therefore, there might be a seventh or magnetic sense, and that it was possible an exceedingly powerful magnetic effect might be produced not to be explained by heat, force, or any other sensation. He then referred to the sense of hearing, describing it as being a sense of varying pressure of air.

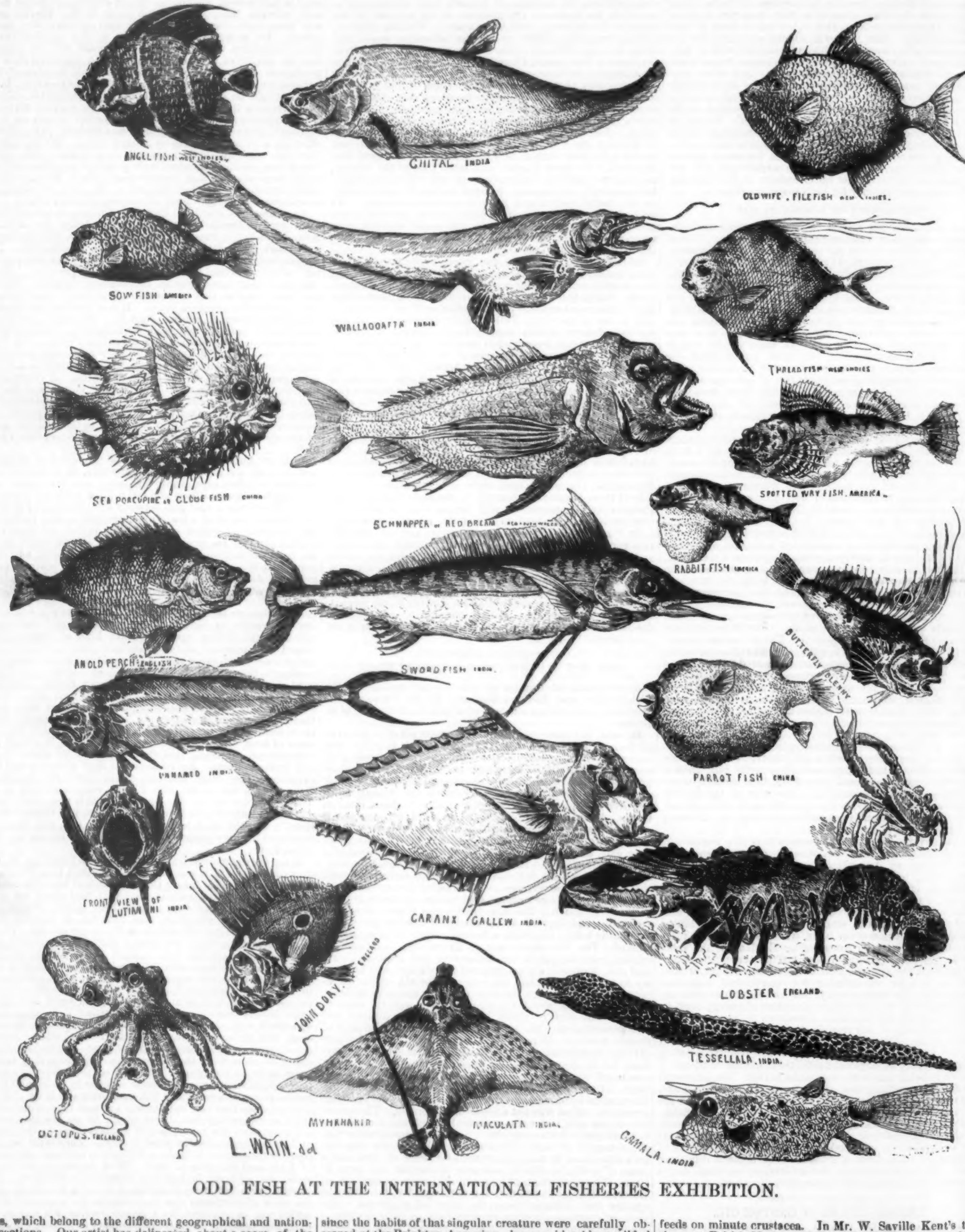
An example of graphical illustration might be taken from the recent mathematical treatise placed before the British Association by the President (Professor Cayley), who insisted very much upon the importance of such illustrations. In the language of mathematics, they had just "one independent variable" to deal with, and that was air pressure. Any one thing that varied was an independent variable. Don't let them imagine that mathematics was harsh and crabby, and repulsive to common sense. It was merely the etherealization of common sense. Now in a thousand counting houses and business places in Birmingham, and London, and Glasgow, and Manchester a curve—as Professor Cayley pointed out—was regularly used to show to the eye the function of one independent variable. Most important in Liverpool, perhaps, might be the price of cotton. A curve was used to show it, rising when the price of cotton was high, and sinking when it was low. So in the Registrar-General's tables of mortality. One of the most beautiful results of mathematics was the means of showing to the eye the law of variation, however complicated, of one independent variable.

Light we know to be an influence on the retina of the eye, and through the retina on the optic nerve, an influence dependent on vibrations, whose frequency was something between 400 million millions and 800 million millions per second. There was a vast gap between 400 vibrations per second and the sound of a tenor note, and 400 million millions, the number of vibrations corresponding to dull red light, the gravest light of the prismatic spectrum. With violet light we had 800 million million vibrations per second, and beyond that there was something which the eye scarcely perceived or did not perceive at all—he believed did perceive, but not vividly—ultra-violet rays, known to us chiefly by their photographic effect, but known also by many other wonderful experiments that within the last thirty years had enlarged our knowledge of light in a marvelous degree. Invisible rays of light falling upon a certain kind of glass—glass tinged with uranium metal, chameleon glass—gave to it, in the absence of all other rays, a mysterious altered color, revealing in that way their presence. The discovery with regard to uranium was made by Professor Stokes, and the property was designated fluorescence. It had since been discovered that fluorescence and phosphorescence were continuous—were extremes of the same phenomenon. But there were other rays which we did not perceive by our sense of heat, and which we called heat rays. It should be remembered, however, that the rays which we called light had heating effects. Radial heat and light were one and indivisible. They were not two things, but were identical. Take a black hot kettle into a dark room and look at it. They could not see it; but let them hold it near their face, and they would receive it by what Bunyan had called "Feel Gate." Put the black hot kettle near the eye, and the eye perceived it—they perceived it, but they did not see it. To define light:

What they perceived was light if they saw it as light, and if they did not see it, it was not light. Radiant heat was light if they saw it. That meant that radiant heat had differences of quality—there was radiant heat that they could see, and radiant heat. When was radiant heat light? When the frequency of its vibrations was between 40 million millions per second and 800 million millions per second. When its frequency was below 400 million millions it was not light, but was only invisible low radiant heat. When its frequency was more than 800 million millions per second it was not light, but became what they called the ultra-violet rays, the actinic or photographic rays. The most subtle of their senses, perhaps, was sight, and next came smell and taste. Prof. Stokes recently said he would rather look upon taste and smell and sight as being continuous, because they all dealt with molecular actions of matter. Prof. Stokes would rather couple these three together than he would couple either of them with the other sense. Perhaps they might know more in the future. Perhaps some of Darwin's sublime speculations might become realities to them, and they might perceive a cultivable retina all over the body. They had not done that yet, but Darwin's grand idea occurred to them as suggesting that there might be an absolute continuity between the perception of radiant heat by the retina and its perception by the sense of heat. They must be content for the present to make a distinction between the sense of light and the sense of heat. With regard to the sixth sense, that of force, he had been vehemently attacked. The physiologists had very strenuously resisted admitting that the sense of roughness was the same as the muscular sense which was experienced by a person feeling his way in the dark, and bringing his hand into contact with some obstacle. The latter was undoubtedly a sense of force, but so also, he contended, was the sense of roughness and smoothness which were experienced in feeling a piece of glass or a lump of sugar between the finger and thumb. The latter had been called by the physiologists the "tactile" sense, but that term did not much enlighten them, since tactile simply meant belonging to touch. The perception of roughness was equally a perception of force with that which had been called the muscular sense, only, instead of the place of application of the force being distant, it was distributed over ten or a hundred thousand little areas.

ODD FISHES AT THE EXHIBITION.

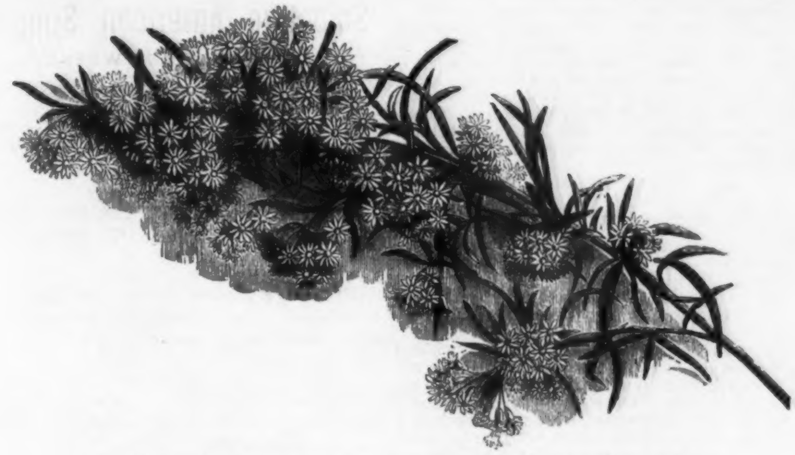
THE visitors to the International Exhibition of Fisheries at South Kensington, London, which closed on the last day of October, 1883, will have been entertained and instructed by the sight of a great many curious specimens of marine natural history. These are to be found not only among the living tenants of the aquarium, which is probably the finest collection of its kind, and is certainly the best arranged, with the most perfect apparatus of congenial water supply, ventilation, and lighting, but also in the collections of preserved specimens, the plaster models, and the colored drawings, which belong to the different geographical and national sections. Our artist has delineated about a score of the queerest-looking creatures to be noticed throughout the Exhibition, some of them already familiar to the British public, as being occasionally met with in our own narrow seas, others from the shores of Eastern Asia or of Australasia, described by learned naturalists. The common lobster, of which there are some very fine live examples in the Aquarium, is a wonderful animal; not properly a fish, but a "crustacean," with the crab, prawn, and shrimp, having their limbs for crawling about connected with the thorax, which is protected, with the head and limbs, by a complete suit of shell-armor, while the eyes, and other organs of perception, are at the extremity of long stalks or antennæ; the powerful claws and mandibles, and the abdomen with its seven-jointed rings, by which the broad swimming-tail is moved, are very conspicuous parts. It is evidently a gigantic insect, and so it is regarded by zoological science; nor is the octopus a fish, but a mollusk of the "cephalopod" or head-footed class, and supposed to be a great enemy of the lobster, whose shell it can easily break with its hard crooked beak after catching hold of it with the eight long flexible arms, furnished with a hundred and twenty pairs of tenacious suckers. Mr. Henry Lee's treatise on the octopus, however, since the habits of that singular creature were carefully observed at the Brighton Aquarium, has considerably modified the exaggerated popular notion of its powers, which had been magnified by Victor Hugo's romantic fancy in his "Travailleurs de la Mer;" but it is a fact that one nearly killed a man diving at Melbourne in 1879, and was only beaten off with an iron bar after twenty minutes' desperate combat. The octopus abounds on the west coast of France, and in some parts of the Mediterranean. The "John Dory," a name which is said to be a corruption of *jaune doré*, or golden yellow, though its color is rather a pale olive brown, with a round black spot on each side, is sometimes offered for sale by our fishmongers, and is much valued for the dinner-table. Its huge head, widely distended jaws, and row of long spines, with interposed slender filaments, above the dorsal fin, add to the grotesque peculiarity of its appearance. Another very queer British fish, but of small size, rarely exceeding three inches in length, is the butterfly blenny, which displays an extension of the dorsal fin ornamented with a round black spot, white edged, bearing some resemblance to a spotted butterfly's wing. This blenny has a remarkably short snout, a twofold crest on the head between the eyes, and its gills are protected by spines. It lives at the bottom among sea-weeds close to shore, and feeds on minute crustacea. In Mr. W. Saville Kent's treatise on "British Marine and Freshwater Fishes," one of the handbooks issued by the International Exhibition Committee, will be found some account of the "Old Wife" (the black sea-bream), which is abundant on our south coast, but which is not always black; its ordinary hue is silver gray, but it becomes almost black after spawning, and quite black after death. There was a tradition that the male bream attached itself to one female mate for life, but this seems to be a fable. Of the file-fishes and the globe fishes, it is stated, one or two species have been captured, but very rarely in British waters.—*Illustrated London News.*



ODD FISH AT THE INTERNATIONAL FISHERIES EXHIBITION.

HELICHRYSUM ROSMARINIFOLIUM.

THE species figured herewith is one of the few shrubby members of the enormous genus Helichrysum. It succeeds well in the open air, at any rate in the south of England—perhaps, to be quite correct, I should say one of the very few which to my knowledge has flourished outside without protection in the southern gardens for some years. A well grown specimen used to be one of the ornaments in the wonderful garden of the late Mr. G. C. Joad, at Oakfield, Wimbledon, and this very plant found its way to Kew with a large miscellaneous collection after that gentleman's death. A glance at the accompanying illustration, which represents a slender branchlet, will give a better idea of the appearance of the species than a column of dry description; suffice it to say that the plant in question is a thoroughly worthy companion to the beautiful New Zealand Olearia Haasti, the golden leaved Cassinia fulvida (Diplopappus chrysophyllus of gardens), and some others of the handsome southern hemisphere composites which in comparatively recent years have been introduced to this country. The little white starry flower-heads are produced in the greatest profusion, but do not last, either on the bush or in water, so long as the larger ones of the Olearia Haasti. The foliage is deep green and, as



FLOWERING SPRAY OF HELICHRYSUM ROSMARINIFOLIUM.

might be inferred from the specific name, very like that of the common Rosemary. The form here figured is the Ozothamnus thyrsoideus of De Candolle, but as that is sunk by Bentham, in the "Flora Australiensis," as a variety under H. rosmarinifolium, and as our plant is known in gardens under the latter name, it is undesirable to attempt to alter existing nomenclature. In a wild state the typical form, which we have not seen in cultivation, is much more common; it differs principally in its somewhat stouter branches being terminated by large, dense corymbs. On the Australian Alps (Victoria), where it ascends to an elevation of from 4,000 feet to 6,000 feet above sea level, and on the banks of the streams in the northern part of Tasmania, it forms a handsome bush from 6 feet to 9 feet in height. To the scientifically inclined who like, for purposes of identification, to have exact data, we may say that under the name we have adopted it will be found fully described in Bentham's "Flora Australiensis," vol. iii., p. 631, and under the name of Ozothamnus rosmarinifolius in De Candolle's "Prodromus," vol. vi., p. 165, and in Hooker's "Flora of Tasmania," vol. i., p. 205.—*G. N., in The Garden.*

GENTIANA ORNATA.

FOR our illustration of this pretty species we are indebted to Mr. Scott Wilson, who further tells us that "it was planted

GENTIANA ORNATA: FLOWERS PALE BLUE

at the foot of a mound in our wood at Wisley, exposed to the sun at the edge of a ditch where the black peaty soil is quite damp, a good sized piece of sandstone having been pushed into the bank for it to root against; at first it did not grow much, but now it has made a fine plant, and has been much admired for its lovely pale blue flowers." As will be seen, it is a species of creeping or trailing habit, with linear glabrous leaves, and tubular funnel shaped blue flowers. It is a native of the higher regions of the Eastern and Central Himalayas, and is fully described by Mr. C. B. Clark in Hooker's *Flora of Br tish India*, vol. iv., p. 116 (1883). It was also figured in the *Botanical Magazine*, t. 6514.—*The Gardener's Chronicle.*

SECOND ANNUAL REPORT OF THE U. S. GEOLOGICAL SURVEY.

THE prestige which the various publications of the Government have acquired at home and abroad, is in no danger of being diminished by the forthcoming monographs of the U. S. Geol. Survey. It will be rembered that at the advice of the National Academy of Sciences, the pre-existing surveys under Wheeler, Hayden, Powell, and King were merged together and compacted into a single organization having regal powers and looking forward, in its exhaustive scheme of geognostical inquiry, to a co-ordinated series of investigations embracing the entire Union. State lines were no longer to exist as artificial boundaries dividing by their arbitrary limits the survey of a district, geographically one, into a number of minor surveys which were lacking in finality, homogeneity, and comprehensiveness. And the novel and difficult problems of the Western Territories were to receive a treatment of the most thorough, direct, and critical kind. For this work, the most advanced and best trained observers and thinkers, the most accomplished experts and thoroughly informed students, were selected. A broad and manifold scheme, embracing subsidiary inquiries of a monumental character, was devised and initiated, and the results of this varied scientific industry at the close of the second year since its inception is now summarized in the bulky volume whose title is given as the subject of this notice.

Clarence King was appointed by President Garfield to be the Director of this imposing department of public affairs, in 1881, but he retired from its direction subsequently, handing over to Prof. Powell the responsibilities and difficulties of this scientific bureau, and leaving in his hands the completion of schemes and plans which, however modified in the future, substantially at present represent the ideas and conceptions of the first director. Prof. Powell's own distinguished service as an explorer and his enlightened zeal in geological inquiry are the best auspices for the survey's future progress and success. Nine elaborate and exhaustive treatises constitute the prodigious outcome of the survey's labors thus far, embracing investigations of collateral interest with the principal subjects of the monographs, and illustrated by atlases and tables of a very composite and interesting nature. One of these monographs, that upon the Tertiary History of the Grand Cañon District, by Capt. C. E. Dutton, has been published, and the others are crowding each other through the government press at Washington. Prof. Powell has included abstracts of all of them by their several authors, in his second annual report as Director, and has himself in its introduction epitomized the contents of these abstracts.

The first subject dealt with is the Grand Cañon district, by Capt. C. E. Dutton. Three remarkable areas, each characterized by generalized features strikingly contrasted, are successively encountered in passing westward from the summit of the long slope which terminates in the Mississippi Valley to the base of the Sierra Nevada. The first is the Park Province, lying in central and western Colorado, a region of mountain ranges, divided and confluent ridges of upheaval; the second is the Plateau Province, situated upon the western boundaries of Colorado, western New Mexico, a large part of southern Wyoming, and more than half of Utah and Arizona; and the third embraces the great basin of Utah, reaching southward into Arizona and northward into Idaho and Oregon. It is characterized by dreary plains, narrow and low mountain ranges, a closed and restricted drainage.

To the second of these, Capt. Dutton has devoted the pages of his monograph. In it lies the stupendous cañon of the Colorado River, and a labyrinthine system of water lines which has engraved its surface with cañons, gulches, and gashes of the most extraordinary and exciting character. The lesson taught by this wonderful display of cliff, pinnacle, and chasm is that of the incalculable power of water to erode and transport matter. The region has also been subjected to violent local displacement and disturbance, faults crossing it in north and south directions, and monoclinal flexures reaching through it. Since the carboniferous period it has been the scene of immense depositions of sediment until the eocene, when through uplifts commenced in the cretaceous it became a circumscribed basin or a series of basins in which lacustrine deposits were laid down. But the uplift, begun at the close of the cretaceous period, had started a wide fluviatile movement whereby the sediments along drainage lines were removed; this continued through eocene and miocene times, with increasing and multiplied activity until, at the close of the miocene, 8,000 to 10,000 feet of strata had been cut through, and wide areas of contiguous territory had been denuded of their mesozoic covering. Then began the excavation of the modern cañon of the Colorado, which has been continued through pliocene and quaternary ages. The startling conclusion summed up after long descriptive chapters of the plateau cliffs, the stairlike succession of projecting strata from the latest to the conglomerate bedding which overlies the carboniferous and ushered in the permian, is that, in the grand cañon district "the area of maximum denudation is from 13 000 to 15,000 square miles, and the average thickness of the strata removed from it was about 10,000 feet." Capt. Dutton's style is vividly influenced by the splendor of the scenery among which he has lived, and the purely scientific discussions connected with it are less salient than the picturesque and enthusiastic flights of word painting.

The second memoir summarized is that by G. K. Gilbert, upon the history of Lake Bonneville. This is perhaps the most characteristic and suggestive paper in the report, and is distinguished by breadth and clearness of enunciation and statement. It discusses the formation and later history of that extensive depression in which Great Salt Lake is now situated, occupying a shrunken area in the great basin which formerly was covered by an inland sea—Lake Bonneville. The interesting observations upon its ancient shore lines, their oscillations, and the two contrasted lacustrine deposits, one overlying the other, the yellow clay and white marl are both readable to a high degree and most instructive. The history of the lake's changes as read in these eloquent sedimentatious shore markings, and subaerial erosions, as deduced by Mr. Gilbert, is as follows:

1. A long period of dry climate and low water, during which the mountains of the desert were buried and the alluvial slopes of marginal mountains were formed.
2. A period of moist climate and high water, during which the yellow clay was deposited and the shore was carried within 90 feet of the summit of the lowest barrier of the basin.
3. A period of extreme dryness, during which the lake disappeared and its salt was buried.
4. A relatively short moist period during which the white marl was thrown down and within which the water overran the barrier, diminishing by erosion its height at the point of discharge.
5. The present period of relative dryness.

The title and subject of the next memoir, of which an abstract is furnished in this report, is The Geology and Mining Industry of Leadville, Lake Co., Colorado, by S. F. Emmons. Mr. Emmons found his district an intricate and troublesome one, and in direct relation to its industrial significance was the importance of thorough investigation and firm conclusions manifest.

Leadville is situated in Lake County, Colorado, on the western flank of the Park Range, the middle range of the three meridional ones in the Rocky Cordillera at this point, and known as the Front, Park, and Sawatch Ranges, commencing in this order with the most easterly. Its rise into a mining center was rapid and accidental. Gold was discovered at the head of South Park, in 1860, and the prospectors adventuresomely pushing further westward and up the Rocky Mountain slopes "stumbled" upon rich diggings near the present site of Leadville. Gold dust was obtained in some quantity, and the city of Oro sprang with necromantic rapidity into existence with 10,000 inhabitants. The gold finds were soon exhausted, but in following the vein leads and working them for the precious metal, large quantities of heavy rock were thrown out which the miners, unacquainted with silver ores, regarded at first as an impediment and as refuse. M. A. B. Wood, a metallurgist, recognized its great value in 1874, and in 1877 the development of the region began in earnest, reaching a climax in 1880, when, from a few log huts and 200 inhabitants, a city of 15,000 inhabitants, with 28 miles of streets, churches, hospitals, banks, and blocks of business houses, has risen. Nothing could be more illustrative of the speed with which human inventions and interests fly to the summons of money and its attractions.

The geology of the Leadville region, while it can be comprehended in a few words, needs for its detailed examination many maps and extended descriptions. Its nucleus is an archæan island upon which sedimentary strata rest; these latter have been sundered and penetrated by extravasations of eruptive rocks and this composite system has been raised, folded into longitudinal ridges, and complexedly faulted.

The ore deposits of Leadville support the following conclusions, which must attract considerable attention:

1. That they have been derived from aqueous solutions.
2. That these solutions came from above.
3. That they derived their metallic contents from the neighboring eruptive rocks.
4. That in their original form they were deposited not later than the cretaceous epoch.
5. That the metals were deposited from their solutions mainly as sulphides.
6. That the process of deposition of the vein material was a chemical interchange or actual replacement of the rock mass in which they were deposited.
7. That the mineral solutions or ore currents concentrated along natural water channels and followed by preference the bedding planes at a certain geological horizon; but that they also penetrated the mass of the adjoining rocks through cross joints and cleavage plains
8. That the main mass of argentiferous lead ores is found in calcareo-magnesian rocks.
9. That the silicious rocks, porphyries, and crystalline rocks contain proportionately more gold and copper.

The ores of Leadville comprise argentiferous galena, carbonate of lead, and chloride of silver. Lead occurs in this region as the sulphate, the phosphate, and oxide, and chloro-iodides and chloro-bromides of silver are frequent.

A very exhaustive report upon the metallurgical features of Leadville will be incorporated in Mr. Emmon's monograph, by Mr. A. Guyard.

The summary of Mr. G. F. Becker's paper upon the geology of the Comstock Lode is of a rather technical and exclusive character, and, though interesting, deals with question not generally known. But other portions, as the history of the lode, are highly valuable and none of it not important and suggestive. Mr. Becker, in studying a field upon which the labors of distinguished engineers and geologists had been expended, felt it incumbent upon him to be careful, thorough, and precise.

Mr. Becker reaches one conclusion important to petrologists—that propylite is not a veracious species of rock, but a result of decomposition, diorite, diabase, and andesite rocks, all changing to this altered form. Decomposition of the most extensive kind has set in among the rocks composing the Comstock Lode, and three features in the process are observable—the formation of pyrite from the bisilicates, decomposition of the bisilicates into chlorite, which is further altered to epidate, and a partial change of the feldspar. In attempting to ascertain the amount of precious metals contained in the rocks of the district with reference to a possible lateral secretion of the vein masses, it was found that "the diabase shows a noteworthy contents in the precious metals, most of which is found in the augite that decomposed rock contains about half as much of these metals as the fresh rock."

Upon the heat of the Comstock Lode and its cause, Dr. Becker has of course much to say. No ratio of any kind was observed between depth and temperature which was of so general application as to permit any calculation as to the subterranean source of the heat, if such is its source. The celebrated hypothesis of kaolinization is discredited, though not denied, and solfataric action invoked, for which many weighty considerations are cited. The summary concludes with an abstract of the experiments made by Dr. Baws on the electrical activity of ore bodies and the thermal effects of kaolinization.

The Production of the Precious Metals in the United States, by Clarence King, follows Dr. Becker's abstract, and A New Method of Measuring Heights by Means of the Barometer, by G. K. Gilbert, concludes the volume. It is hoped to indicate the results contained in the former paper in another notice. The results of Mr. Arnold Hague's survey of the Eureka region, Nevada, are embraced in the administrative reports from heads of departments.

L. P. Gratacap.

GREAT SALT LAKE.

By Marcus E. Jones.

With several members of the Agassiz Association an excursion trip was taken lately on Great Salt Lake. Going out to Lake Shore on the swift little Rio Grande train, we landed in about half an hour and found our boat waiting for us. After stowing away our collecting bottles and cans, insect nets, egg baskets, hammers, and other paraphernalia, we breathed easier, knowing that as long as they were out of sight no old toper would ask for a drink of our alcohol and corrosive sublimate, that no one would take us for perfumery and comb peddlers, nor wink with Western shrewdness at the idea of catching fish in the lake. At the pier we found the water only a foot deep, where two years ago it was three or four. Even the mud was furrowed up by boats which had come up to the landing.

Hoisting our sail, we passed out toward the middle of the lake. For six or eight miles, we sailed over water that was nowhere more than two or three feet deep. Some five or six miles out we struck broad patches where the bottom was covered with the dead shells of fresh water mollusks, washed in from Hot Spring Lake, caught by the roots and stems of the salt grass and some bulbous plants, which forty years ago flourished there and were overwhelmed by the rising brine, and perfectly preserved for a generation. The water has so nearly reached its level of 1840 that the high waves wash up the roots and cast them upon the beach, where they are now to be found. The storm line of that year is now at the water's edge, and the ancient sagebrush that grew immediately behind it now stands like ghostly sentinels over their graves. For over forty years this same sagebrush has stood deep beneath the water, like the submerged forests of the Columbia River.

A stiff breeze soon sprang up from the south, and we went booming along in full view of Antelope (Church) Island, toward a dim, low island (Fremont's) to the north of it. Night dozed around us; midnight came and went, and just as Fremont Island loomed up in the darkness, a great red finger rose rapidly behind the distant Wahsatch, and towering up, seemed to bend toward us as if to warn us not to disturb the island's solitude. The new moon never seemed so awe-inspiring nor more unlike itself as it rose half out behind the hills.

FREMONT ISLAND.

Ere long the gravelly shore of Fremont Island was reached, and soon all the party were fast asleep on the beach. One of them had taken the precaution to tie the halliard rope around his body, and in about two hours he found himself traveling toward the water, the strong waves having loosened the boat. About dawn he was again doubled up by the rope. Had it not been for this precaution, all the party would have graced the solitude with their presence, and the boat would have sailed alone. The next morning most of us studied the ancient beach of the island, and gathered splendid specimens of specular iron ore and slate. Our geological books informed us that the island was a mere pile of rocks, barren, and without water; what was our surprise, therefore, to find it smooth and rounded, with but few cliffs and dotted with sheep, which of course meant at least one good spring upon it. Descending to the shore, we found the sand to be angular, like that of the ocean and most fresh water lakes, this being almost the only place where the peculiar oolitic (egg-shaped) sand of the lake is absent.

Soon we were on our way toward the hazy western shore. As we passed along, the sea gulls circled around us or floated on the water, their white plumage shining in the sunlight. Every now and then a hawkmoth would flit by or alight on the boat, dragon flies would stop long enough to gaze at us curiously, and then spin off toward the distant islands. Occasionally a 17-year locust would hum past as if to mock at us for ever daring to believe that this is the

"DEAD SEA OF AMERICA."

As the bow plowed through the water, millions of small *diptera* (flies) would rise from the water, where they were resting, and cover the bow of the boat till quarts of them could be collected. Wherever we went we observed the same thing. The water of the lake is their home, and they are as much at ease sitting on the water as a skipper is on an Eastern pond. In some places when it is calm these flies darken the water for miles. Here (not on the beach) they lay their eggs; here they hatch, and here the larvæ live by the million till ready for the pupa state, when they attach themselves to the seaweed (floating everywhere in the water) and remain till they emerge as perfect flies. The larvæ doubtless prey upon the strange little shrimps that live in the water. There are infinite numbers of these, as there is scarcely a place in the lake where a bucket of water can be dipped without taking up from 20 to 500 of them. It is strange that people should call this a "dead sea," for though the number of species does not exceed 10 or 15, there is no lake, fresh or salt, in the world that contains half as many living things as Great Salt Lake.

SMALL ISLANDS.

In the course of the forenoon we reached and explored several small islands near the western shore, then passed around the northern shore of

STANSBURY ISLAND.

This is the most interesting of all the islands of the lake. We had previously explored it, finding some very rare plants, insects, and fossils. The eastern side is indented by numerous open bays, which sweep from point to point in arcs of circles like so many bended bows. The beach is composed of fine white sand, free from bowlders, and slopes quickly to the water, where it forms a beautiful bottom. A few rods from shore the water is deep enough to satisfy the most fastidious, thus making the most delightful bathing places on the lake. The view obtainable from the island's lofty peaks is unexceled.

Leaving Stansbury behind, we sailed for the north shore of

ANTELOPE ISLAND,

passing over the deepest water in the lake. When we reached the shore, the breakers were rolling so high that we could not land. Passing around the point we soon reached some springs of water, where we quenched our thirst and refilled our empty cask. Here we saw considerable stock upon the hills.

The remainder of our trip to Lake Shore was without incident till we had almost reached the landing, when a terrific squall dropped upon us from the mountains near by, and almost lifted us out of the water. The waves hissed by and almost laid bare the bottom; when they struck us it seemed like so many Titan sledge hammers trying to shatter the boat. There is probably but one sea in the world where the shock of the waves is so terrific, not from the force of the wind, but from the extreme heaviness of the water. Though the lake has the reputation of being treacherous, we soon learned that it has some very good points. From 5 A. M. to 4 P. M. the wind usually blows steadily from the north or northwest; then there is a calm of an hour or two, when it blows from the south nearly all night.

Our three days' sail of 110 miles was voted a success by all. The breezes were comparatively gentle, not frightening anybody (as they did on a former trip, when the waves were seven feet high); the heat was not intense, the sea seemed so like a fresh water lake, and animal life was so abundant in and around it, that we shall never again call this the "Dead Sea of America."—*Min. and Sci. Press.*

ALASKAN EXPLORATION.

Lieut. Schwatka, of Arctic fame, who, with his party, was picked up by Lieut. Ray at St. Michaels, speaking of his recent trip up the Yukon River, Alaska, says they started from Fort Vancouver, Washington Territory, on May 21, being detailed by Gen. Miles, commanding the Department of Columbia, to make an exploration of the valley of the Yukon. He traveled 2,800 miles overland, reaching the headwaters of the river, where they constructed a raft of logs to navigate the stream to its mouth. They procured a crew of six Indians and proceeded down the gradually increasing stream within 250 miles of Fort Chilcat, when rapids were encountered. Down them the Indians refused to go, and attempted to force the raft ashore. Schwatka, in order to suppress the mutiny, opened fire on the Indians, killing three, when the others submitted, and the rapids were run. The voyage on the raft was 1,829 miles. From the mouth of the Yukon, they proceeded to St. Michaels, where they boarded the Leo for this port.

Lieut. Schwatka claims that he has been further up the Yukon than any other white man. This is denied by Signal Service Officer Leavitt, who has been stationed at St. Michaels, and who also came down on the Leo. He says he ascended the Yukon to Fort Selkirk, 20,00 miles from its mouth. He describes the river as being one of the largest in the world, discharging 50 per cent. more water than the Mississippi, and as being at places seven miles in breadth.

Lieut. Storey, who went upon the last trip of the revenue steamer Thomas Corwin for the purpose of distributing among the Tchuckchee Indians, of Alaska, the $5,000 worth of presents given by the Government in recognition of the fact that they afforded shelter and food to the officers and crew of the steamer Rogers, burned in 1881, reports the discovery of an immense river hitherto unknown to geographers. The river had been vaguely spoken of by Indians to former explorers, and Lieut. Storey, being compelled to await the return trip of the Corwin, determined to see if it existed. Accompanied by one attendant and an interpreter he proceeded inland from Hotham Inlet in a southeasterly direction until he struck what be believed to be the mysterious river. He traced it to its mouth, a distance of about 15 miles, where he saw such huge pieces of floating timber as to satisfy him that the stream must be of immense size. He retraced his steps for a distance of 50 miles, where he encountered natives from whom he learned that to reach the headwaters of the unknown stream would take several months. The Indians told him that they had come down the river a distance of 1,500 miles to meet a fur trader, and that it went up higher than that. Having no time to go further, Lieut. Storey returned. It is his opinion, as stated by those on the Corwin from whom this information was obtained, that the discovery of this river accounts for the large quantities of floating timber in the Arctic Ocean, which has popularly been supposed to come down the Yukon River. The Indians stated that the river in some places is 20 miles wide. It lies within the Arctic circle, but in August, when Lieut. Storey was there, he found flowers and vegetation not hitherto discovered in so high a latitude. He has forwarded his report to the Secretary of the Navy, and hopes, to be permitted to go back and continue his explorations.

FEVER FROM BAD MILK.

During the last few years rapid strides have been made in the investigation of diseases that may be transmitted directly or indirectly from the lower animals to man. It seems to be proved beyond doubt that foot-and-mouth disease is communicable by immediate contagion, and also by the unboiled milk of cattle suffering from the epidemic, even when the udders and teats are not visibly affected. With equal certainty outbreaks of enteric fever and other specific disorders incidental to humanity have been traced to the use of milk, although, as pointed out in our last issue, it is a moot question whether the milk obtained from infected districts is charged with the poison during the process of secretion, or whether it becomes subsequently contaminated by admixture with impure water. At the present time there is a serious outbreak of enteric fever in Dundee, which appears clearly traceable to the milk-supply of the locality invaded.—*Lancet.*

TABLE OF CONTENTS.

Household